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Geometrical L I N E S

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to work by.

By WILLIAM HALFPENNY,
Architect and Carpenter.

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and JOHN WALTHOE at *Richmond*. M.DCC.XXV.

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To the Honourable
Sir *ANDREW FOUNTAIN*, Knt.

S I R,



IS with Pleasure I lay the following Piece at your Feet, as being convinc'd I do it to one who is an absolute Judge of the Merits thereof. You, Sir, are perfectly sensible of the Necessity and Usefulness of a Work of this Kind, and will readily perceive the Industry and Pains used in the Compiling of this. Your Taste, Sir, will easily point out to you what is good in it, and what deficient; and your Humanity will lead you to countenance and recommend the one, as your Love to the Art will move you to correct the other. In Effect, Sir, if I make my Address to you, 'tis less as a Patron than as a Judge: Your

DEDICATION.

Censure I stand in more Awe of than that of the Publick; as I reckon 'tis that will determine this.

AN uncommon Penetration, an exquisite Judgment, a delicate Taste, and a thorough Acquaintance with the Subject of a Book, are Qualities much to be feared by a Dedicator: And I will add, they are Qualities it had been so easy to have found a Patron without, that it ought to be a Presumption of some Merit in the Work, that I dare to dedicate it to Sir *Andrew Fountain.*

I am, S I R,

With entire Submission,

Your Humble Servant,

WILLIAM HALFPENNY.



THE



THE P R E F A C E.



THE Reasons that first induced me to publish this *Work*, was the daily Errors that I saw *Workmen* commit in framing their *Works* for *Buildings*, on account of their *Want* of the Knowledge of the Proportions contain'd in this *Book*, being the only Thing, that I know of, that is wanting to make the *Art* of *Building* complete.

HERE I would not be thought to be so vain, as to teach our *Architects*; neither do I believe they are insensible of the Usefulness of this, or much greater *Works*; but rather blame them for keeping so advantageous a *Work* from the Eyes of the *World*.

IT is certainly every *Man's* Duty to reveal whatever he thinks may be of Service to the *Publick*; and so I have shewn the Nature of all Kinds of *Arches* in this *Work*, and laid down easy and practicable *Ways* of drawing and working of them,
so

The P R E E A C E.

so that any Workman, with a little Pains, may understand the Nature, true Butments, and Intersections of all Kinds of Arches, from whence he may strengthen and very much beautify them, especially Irregular Groins, which have been made very ill, for want of knowing, when the Arch of either Spand being given, what must be the Arch of the other, so that the Intersection of them shall beget the Groin to stand perpendicularly over its Base.

THEREFORE I earnestly desire all Workmen to lay aside erroneous Methods, and peruse this short Track of mine, or some other, that so both they and their Art may get Reputation thereby.

I HAVE thought fit to say thus much by way of Preface; and as for the rest let the Work answer.

WILLIAM HALFPENNY.



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THE ART of SOUND BUILDING.

SECTION I. *Of the Description of ARCHES by the Intersection of Lines, &c.*

PROBLEM I. *How to erect a Perpendicular from the Middle of a Right-Line given.*

PLATE I. FIGURE I.

The given Right-Line is A B, and C is the middle Point thereof ; Upon which it is required to erect the Perpendicular.



FIRST open your Compasses at Pleasure to any Distance, greater than half the Line, and setting one Foot in the Point A, with the other sweep the Arch *ee*; this being done, with the same Opening of your Compasses set one Foot in B, and with the other sweep the Arch *dd*. Then from the Point where these two Arches cut one another, draw a Right-Line to the Point C, and that Line will be perpendicular to the given Line A B.

P R O-

P R O B L E M II.

How to erect a Perpendicular from the End of a Right-Line given.

F I G U R E II.

Let the given Right-Line be AB, and B the End from which it is required to erect a Perpendicular.

FIRST open your Compasses to any convenient Distance, and setting one Foot in B, mark that Distance five Times in the Line AB from B to C, so that BC be divided into five equal Parts. Then taking four of those Divisions in your Compasses, as from D to B, set one Foot upon the End of the Line B, and strike the Arch *dd*; and afterwards opening the Compasses to the Distance of five of those Parts, or the Length CB, set one Foot in E, the End of the third of the equal Parts from B, and with the other strike the Arch *ee*. This being done, if a Line be drawn from the Point where the two Arches cut one another to the Point B, that will be a perpendicular to AB.

P R O B L E M III.

How to describe a Scheme-Arch, when the Length of the Base and Perpendicular are given.

F I G U R E III.

Let the Length of the Base AB be five Foot, and let the Perpendicular CE be one Foot: The Arch ACB is required to be drawn.

FIRST draw the Base AB five Foot, and halve it at E, and from E raise the Perpendicular EC of one Foot in Height; then lay a straight Rule on the two Points C and E, and draw a Line at Pleasure from
E

E towards G. This being done, draw the Hypothenufal Line C B, and halve it at D; and taking the Length of this Line C B, either with a Line, or Beam Compafs, or common Compafs, (if they will open wide enough,) from the Point B fweep the Arch *ii*, and from the Point C, the Arch *h h*; then from D, thro' the Interfection of the two Arches, draw a Line to cut the Line C G at F, and F will be the Center of the Arch; to be drawn about which, you may describe the fought Arch A C B with the Distance F C.

P R O B L E M IV.

How to draw a Scheme-Arch, without finding the Center thereof, the Base and Perpendicular being given.

F I G U R E IV.

Let the Base A B be five Foot, and the Perpendicular E D be one Foot, the Arch A D B is required.

FIRST draw the Base A B five Foot in Length, and halve it at E, and on E raise the Perpendicular E D, equal to one Foot, the Height of the Arch, and continue it to C, so that C D be likewise one Foot; and from the Point C to the Points A and B, draw the Lines C A and C B. This being done, divide each of them into an equal Number of equal Parts at Pleasure, (the greater the Number is, the exacter will the Work be,) one of which, in this Example may be about two Inches; then if straight Lines are drawn from the Points of Division, 1, 2, 3, &c. of the Line A C to the Correspondent Points of Division 1, 2, 3, &c. of the Line C B, the Points wherein every two of these Correspondent Lines cut one another, will be in the Arch required; and so the Arch A D B will be made by drawing these Lines, equal to the Arch A C B, of *Figure III*.

P R O B L E M V.

How to draw a rampant-Scheme Arch.

F I G U R E V.

FIRST draw the prick'd Line A B, to represent the Width of the Door, or Window, upon which the Arch is to stand, and halve it at G, and from the Point B raise a Perpendicular B C, equal to the Ramp of the Arch, and draw the Base Line A C; then from G raise a Perpendicular to A B, which will cut the Base A C in half in F, and continue it to D, so that F D be equal to twice the Heighth the Arch is to rise, that is, twice F E. Having done this, from the Point D to the Points A and C, draw the Lines D A and D C, each of which divide into an equal Number of equal Parts at Pleasure, as 1, 2, 3, 4, &c. 1, 2, 3, 4, &c. which may be each about two Inches: If A B be four Foot, and F E one Foot; then if streight Lines are drawn from the Points of Division, 1, 2, 3, 4, &c. of the Line A D, to the correspondent Points 1, 2, 3, 4, &c. of Division of the Line C D, the Points wherein every two of these correspondent Lines cut one another, will be in the Arch required; and so the Rampant Scheme-Arch A E C will be made, which was required.

Note, When the Point C is the same as B, or when it comes down to B, then will the Arch A E C be equal, and like to those of *Figure III.* and *Figure IV.*

P R O B L E M VI.

How to describe a Semicircular Arch by the Intersection of Streight Lines.

F I G U R E VI.

FIRST draw the Base Line A B, and halve it at C, and at the Point C raise the Perpendicular C G, equal in Length to C A, or C B; then divide the Semidiameter

meter AC into seven equal Parts, and continue it out to D; so that AD be two of those Parts. This being done, take CD in your Compasses, and setting one Foot in C, with the other strike the Arch DF, of a Length at Pleasure; then with your Compasses, open'd to any convenient Distance, from A and G sweep the Arches *k* and *e*, and through their Intersection, and the Point C draw a straight Line, cutting the Arch DF in the Point E, and draw the Lines A E and EG. Again, take A E, or E G, in your Compasses, and from the Points B and G strike the Arches *i* and *h*, and from the Intersection of these two Arches draw Lines to G and B; and if the four equal Lines last drawn be each divided into the same Number of equal Parts, and correspondent intersecting Lines are drawn, according to the Directions of the two last Problems, they will describe the semicircular Scheme-Arch A G B required.

P R O B L E M VII.

How to draw a Rampant Semicircular Arch.

F I G U R E VII.

FIRST draw the Lines A G and G I, and I I and B I, all equal to one another, after the very same Manner as the Lines A E and E G, and G h and B i, all equal to one another, ^{as} are drawn in Figure VI. and also draw the Arch EH at Pleasure here, as you did the Arch DF there, and the Line G D here, as the Line E C there. Then from the Point B raise the Perpendicular BC, representing the Heighth of the Ramp, and draw the Base Line AC, which will be halved by the Perpendicular DI in the Point F. This being done, continue the Perpendicular DI to K, so that F K be equal to DI, that is, take DI in your Compasses, and set it from F to K, and draw the Lines A G and G K; then take G K in your Compasses; and setting one Foot in K, with the other strike the Arch *m*; also take the Length A G between your Compasses, and with one Foot in C sweep the Arch *n*, and from the Point of Intersection of these two Arches

C

draw

draw Lines to K and C, and divide the four out Lines last drawn, each into the same Number of equal Parts, and draw the intersecting Lines according to the Directions above given, and they will describe the sought Arch AKC.

P R O B L E M VIII.

How to draw an Elliptick Arch to any Width and Height, when the Height is greater than the Width, by the Intersection of straight Lines.

F I G U R E VIII.

FIRST draw the Base Line AB, and raise the Lines AC and BD, Perpendicular to the same, and each equal to your designed Height, and draw the Line CD, which halve in the Point E. This being done, divide the Lines AC and EC, and ED and DB, each unto the same Number of equal Parts, and draw intersecting Lines according to the Directions above given, and you will have the Arch required AEB.

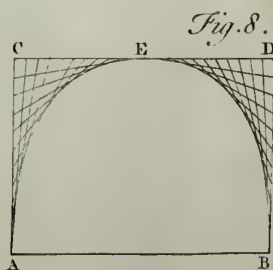
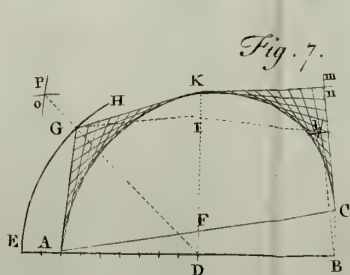
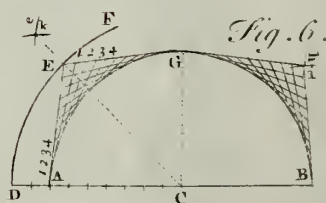
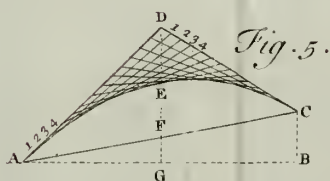
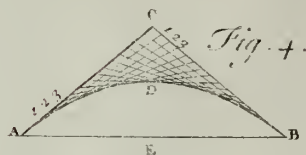
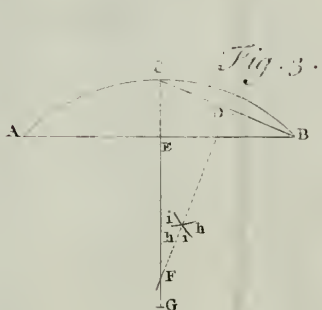
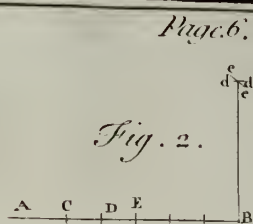
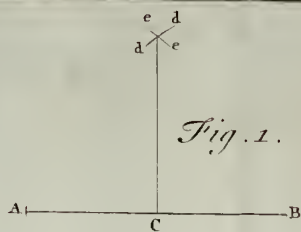
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P R O B L E M IX.

How to describe an Elliptick Arch to any Width and Height, when the Height is less than the Width, by the Intersection of Lines.

F I G U R E IX.

FIRST draw the Base Line AB, and from the Ends, A and B, thereof raise the Perpendicular AC and BE, each equal to your designed Height, and draw the
Line



Line CE , which halve in the Point D . This being done, divide the Lines AC and CD , and DE and EB , each into the same Number of equal Parts, and draw the intersecting Lines according to the Directions above given, and you will have the Arch ADB required.

P R O B L E M X.

How to draw an Elliptick Arch by Means of a Tramel.

F I G U R E X.

FIRST make the Tramel $ABCi$ in the same Form as it is represented in the Figure, where the Leg Ci is at Right-Angles to the Head AB , both of which have Grooves in the Middles of them for the Pins e and f , which are fastened to the Rule or Lath DH , of a Length greater than iB , the half of the Base of the Arch to slide in. Then if the wooden Pins e and f are fix'd in the Lath at such a Distance from one another, that when a Pencil, or any Thing else proper to make a Mark with, is put through a Hole g , made in the same with a small Gimblet, the Length eg is equal to iB , the Half of the Base Line of the Arch, and the Length fg equal to the Heighth the Arch is to arise, and the Tramel be fix'd fast in the Place, you Design to strike the Arch upon, and the Pencil g be put in the Point A , and the Pins f and e in the Grooves AB and ic , and with one Hand you move the Pencil g , and with the other guide the Pins e and f in their respective Grooves, when the Pencil is come to A , it will describe the Elliptick Arch AHB required.

P R O B L E M XI.

To draw a Rampant Elliptick Arch by the Intersection of straight Lines.

F I G U R E XI.

FIRST draw the prick'd Right-Line AB , and from B erect the Perpendicular BE equal in Length to the Heighth of the Ramp, and continue it out to H , so that EH be equal to the Heighth of the Arch, and draw the Line AE . Also at the Point A draw AF Perpendicular to AB , and equal to EH , or the Heighth of the Arch, and from the Points F and H draw the Line FH , which halve in G . This being done, divide the four Out-lines AF and FG , and GH and HE , each into the same Number of equal Parts, and draw the intersecting Lines as above directed, and you will have the Arch AGE , which was required to be drawn.

P R O B L E M XII.

To draw a Gothick Arch, or Oxi, when the Heighth is greater than the Width, by the Intersection of straight Lines.

F I G U R E XII.

FIRST draw the Base Line AB , and halve it at C , from which erect a Perpendicular of a Length at Pleasure, and in it set off the Heighth of the Arch CF , and at the Points A and B raise the Perpendiculars AD and BE , each equal in Length to half the Heighth CF , and draw the Lines FD and FE . This being done, divide the four Out-lines AD and DF , and FE and EB , each into the same Number of equal Parts, and draw the intersecting Lines as before directed, and they will make the Arch AFB , which was required to be drawn.

P R O B L E M XIII.

To draw a Gothick Arch, or Oxi, when the Heighth is less than the Width by the Intersection of straight Lines.

F I G U R E XIII.

FIRST draw the Base Line AB, and halve it at C, from which erect a Perpendicular of a Length at Pleasure, and in it set off the Heighth of the Arch CE, and at the Points A and B raise the Perpendiculars AD and BF, each equal in Length to half the Heighth CE, and draw the Lines DE and FE. This being done divide these four Out-Lines AD and DE, and EF and FB, each into the same Number of equal Parts, and draw the Intersecting Lines as before directed; and they will form or make the Arch AEB, which was required to be drawn.

Note, If the Arch is required to be quicker or flatter on the Hanse, it is but lengthening, or shortening the Perpendicular Lines AD and BF.

P R O B L E M XIV.

To draw a Rampant Gothick Arch, or Oxi, by the Intersection of Lines.

F I G U R E XIV.

FIRST draw the prick'd Line AB, and halve it at C, and from B raise the Perpendicular BE, equal in Length to the Heighth of the Ramp, and draw the Line AE, and from C draw CG perpendicular to AB, in which take DG equal to the Heighth of the Arch. Then at the Point A raise the Line AF perpendicular to AB, and equal to one Half of the Heighth of the Arch, and continue BE to H, so that EH be also equal

D

to

to half that Heighth, and draw the Lines FG and GH. This being done, divide these four Lines AF and FG, and GH and HE, each into the same Number of equal Parts, and draw the Intersecting Lines as before directed, and they will form or make the Arch AEB, which was required to be drawn.

P R O B L E M XV.

To strike or draw Gothick Arches by Means of other Arches.

F I G U R E XV.

FIRST draw the Base Line AB, and set off the Thickness of the Arch from A to C, and from B to O, and divide CO into three equal Parts in the Points D and E, about which describe two Half-Circles C*i*E and D*n*O. Then taking **CE**, or DO, each of which is two Thirds of CO, between your Compasses, and setting one Foot in C, with the other sweep the Arch EF, and the Compasses remaining open'd to the same Distance, set one Foot in E, and sweep the Arch CF. And in like Manner sweep the Arches DG and OG, from the Centres O and D, and from the Intersection of the two Arches at F, through the Centre E, draw the straight Line FM, and from the Intersection of the two Arches at G, thro' the Centre D, draw the straight Line GH. The Centres D, E, F, and G, being thus found, take AD in your Compasses, and setting one Foot in D, with the other strike the Arch AH, in like Manner, with the same Distance, and one Foot in E, draw the Arch BM. This being done, take Fn between your Compasses, and setting one Foot in G, strike the Arches *i*K, and HL, and also with the same Distance, and one Foot in F, describe the Arches *n*K and LM, and the required Arch CALBO is drawn.

Fig. 9.

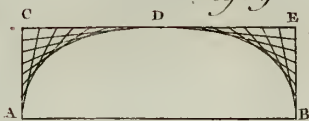


Fig. 10.

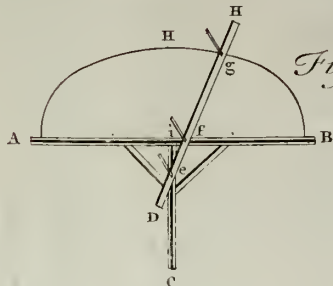


Fig. 11.

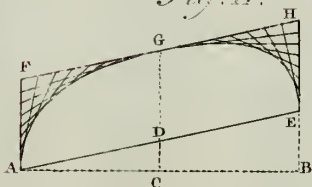


Fig. 12.

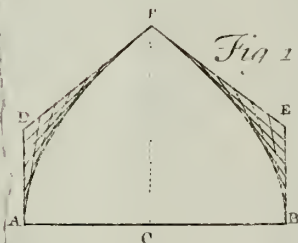


Fig. 13.

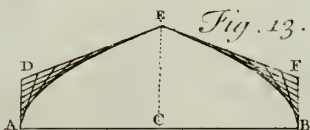


Fig. 14.

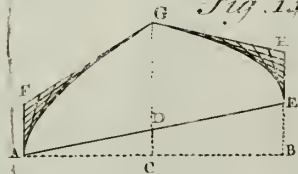


Fig. 15.

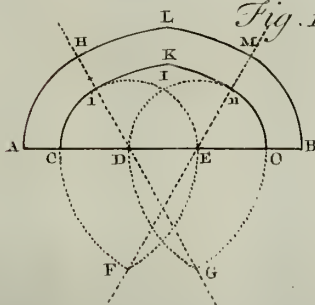
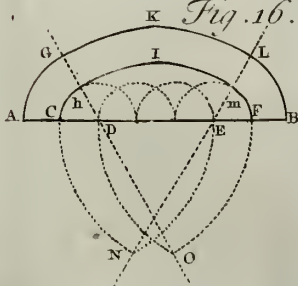


Fig. 16.



P R O B L E M XVI.

To describe or draw a Gothick Arch of another Kind by Means of Circular Arches.

F I G U R E XVI.

FIRST draw the Base Line A B, and set off the Thickness of the Arch from A to C, and from B to F, and divide C F into five equal Parts, upon which describe four equal Half-Circles, D and E being the Centers of the outermost ones. This being done, extend your Compasses from F to D, or from C to E, and setting one Foot in F, with the other strike the Arch D O. The Compasses remaining thus open'd, set one Foot in D, and with the other draw the Arch O F. In like Manner, upon the Centers F and E with the same Distance, draw the two Arches C N and D O. Then from the Intersections N and O of these two Arches, through the Centers E and D of the outermost Half-Circles, draw the straight Lines N L and O G of Lengths at Pleasure, and on the Centers E and D, with the Distance E B, or A D, between your Compasses, strike the Arches B L and A G. Moreover, extend your Compasses from O to O *h*, or from N to *m*, and with one Foot in O, draw the Arch *h* I, and with one Foot in N, the Arch *m* I. Lastly, take the Distance O G, or N L, in your Compasses, and on the Centers O and N draw the Arches G K and K L, and the Arch C A K B F will be finished.

The End of PLATE II.

P R O B L E M X V I I .

*To draw a Shipwright's Arch, by the Intersection
of straight Lines.*

F I G U R E X V I I .

FIRST draw AB, the Base Line, and from A and B, the Ends thereof, erect the Perpendiculars AC and BE, whose Difference in Length or Heighth must answer to the Rake of the Arch, or Ceiling of the Cabin, and draw the Line CE, which halve in the Point D. This being done, divide AC and CD, and BE and ED, each into the same Number of equal Parts, and draw the Intersecting Lines as is taught in the foregoing Problems, and they will form or make the required Arch ADB.

P R O B L E M X V I I I .

*To draw a Bow-Arch by the Intersection of straight
Lines.*

F I G U R E X V I I I .

FIRST draw the Base Line AB, and halve it ^{at} C: Then draw the Line GH of a Length at Pleasure, parallel to AB, or perpendicular to CE, (which is a Perpendicular to AB, drawn from the Middle Point C,) and at a Distance from it, equal to the Heighth of the Arch, and draw ~~the Lines AD and BF.~~ Then take CE in your Compasses, and set it off from E to D, and from E to F, and draw the Lines AD and BF. This being done, divide the Lines AD and DE, and BF and EF, each into the same Number of equal Parts, and draw the Intersecting Lines as is taught in foregoing Problems, and they will form or make the required Arch AEB.

Note,

Note, The aforefaid Arch is very neceffary to be ufed in wide Spands, or Spaces, where there is not Conveniency to raife a Semicircular Arch, as in Vaults under Streets, or Arches of Bridges, where great Strength is required, becaufe the Butments of this Bow-Arch are much ftronger than thofe of Gothick Arches, Elliptick ones, or any Scheme ^{or} Semicircular Arch.

P R O B L E M XIX.

To draw the two different Edges of a Twisted Schofeet.

F I G U R E XIX.

THE nineteenth Figure represents the inward and outward Edges of a twifting Schofeet of a Semicircular Door, or Window, whose Jaums, from the Beginning to the Springing of the Arch, fplays more or lefs, according to the Humour of the Builder, and whose Crown lies level without fplaying, the outward Arch CFD being even with the Head of the Window-Cafe. Now the Question is, how to find the inward Edge AFB, fo that it fhall diminish gradually from nothing at the Crown F, to the Splay of the Jaums at the Springing AC and DB.

FIRST draw the Bafe Line AB equal to the Width of the Window and Splays of both Jaums, and halve it at H, and from it raife the Perpendicular HF to AB, and fet the Splays inwardly from A to C, and from B to D. This being done, extend your Compaffes from H to D, or from H to C; and fetting one Foot in H, with the other ftrike the Semicircle CFD, and draw the Line IK of a Length at Pleafure, parallel to the Bafe Line, and at a Distance from it, equal to the Heighth of the Arch CFD; and take the Height HF between your Compaffes, and lay off that Heighth from F to E, and from F to G in the Line IK, and draw the Lines AE and BG. Laftly, divide the Lines AE and EF, and BG and FG, each into the fame Number of equal Parts, and draw the Interfecing Lines as is

E

taught

taught the foregoing Problems, and they will form or make the Arch AFB, which will splay gradually from nothing at F to AC and DB, which is what was required to be done.



S E C T I O N II.

of GROINS.

P R O B L E M. XX.

To find the Angle, or Mitre-Bracket of a Cove.

F I G U R E XX.

FIRST draw the Base AB of the regular Bracket, and from A draw AD, perpendicular and equal to it, and draw the Line DB, and continue the Line DA to C, so that AC be also equal to AB; then extending your Compasses from A to B, and setting one Foot in A, with the other describe the Arch, or Quarter of a Circle CB, and from the Point D draw DF, perpendicular to DB, and equal to DA, or AC, and another as BE from B, likewise equal to DA, and draw the Line FE, which will be parallel to DB. This being done, divide AB into a Number of equal Parts, not exceeding two Inches and an half, and thro' the Divisions of them draw Lines parallel to AC, to touch the Arch CB, which continue out to the Line DB, and this Line will be divided likewise into the same Number of equal Parts, as AB is. Lastly, from the Divisions of the Line DB, draw Lines Parallel to DF, and in each of them, from DB, lay off its Respection Parallel, (from AB to the Arch BC,) and at the Points whereat they end stick small Nails, or Pins, and take a thin Lath, and bend it

it round the Nails, or Pins, observing that it touches them all, and with a Pencil, or any Thing else, proper to make a Mark, describe the Arch FB round the Edges of the Lath; and this is the Arch for the Angle, or Mitre-Bracket.

P R O B L E M XXI.

To find the Angle, or Mitre-Arch of a Regular Groin, when the Intersecting Arches are Semicircles.

F I G U R E XXI.

FIRST draw the Line AB , and from the Ends A and B thereof, let fall the Perpendiculars AC and BD to it, and each of the same Length as it, and draw the Line CD ; then halve the Line AB in e , and with the Distance Ae , or eB , about the Center e , describe the Semicircle AFB , and draw the Line AD . This being done, at the Points A and D raise the Lines AG and DH perpendicular to AD , each equal in Length to the Height of the Semicircle eF , and draw the Line GH . Lastly, divide the Line AB into any Number of equal Parts, thro' the Divisions of which draw Lines to touch the Semicircle AFB , parallel to BD , and to divide the straight Line AB ; then if Parallels to AG are drawn from the Divisions of AD , and in each of them from AD , is set off its Correspondent Parallel, (from AB to the Arch AFB ,) and at the Points whereat they end be stuck in Nails, and a thin Rule be bent round them, so as to touch them all, a Pencil, or other Thing proper to make a Mark, being mov'd round the Edge of the Rule, will describe the Arch AiD , which is the Angle, or Mitre-Arch of a Regular Groin.

P R O B L E M XXII.

To find the Angle, or Mitre-Arch of a Regular Groin, when the Intersecting Arches are Gothick ones, viz. such as are shewn how to be drawn in Figure xv.

F I G U R E XXII.

FIRST draw the Lines AB, BD, DC, AC, and AD, in the Manner as was shewn in the last Problem, and upon AB and BD describe the Gothick Arches AFB and BLD, according to the Directions laid down in *Problem xv*. Then divide the Line AB into any Number of equal Parts, and from the Divisions thereof draw Parallels to BD to touch or come to the Arch AFB, and divide the Line AD, and at the Points A and D raise the Perpendiculars AG and GH, each equal to Fe, and draw the Line GH. Then draw Parallels to AG from the Divisions of AD, and in each of them from AD set off its Correspondent parallel, (from AB to the Arch AFB,) and at the Points whereat they end, stick in Nails. This being done, if a thin Rule be bent round them, so as to touch them all, and a Pencil, or other Thing proper to mark with, be moved round the Edge of the Rule, the Mitre-Arch AID will by this Means be described.

Note, In this Figure, and all others, whose Hanfes rise quick, after you have made the equal Divisions, and drawn the Parallels according to the foregoing Rules, before you describe the Arch sought, divide the first and second Division next to the springing Foot of every Arch, each into two equal Parts, from whence draw other Parallels as is before taught, and set off their Heighths or Lengths in the other Parallels; and by this Means your Hanse will have its true Bearing, and not be crippled.

P R O B L E M XXIII.

If the lesser Arch of an Irregular Groin be a given Semicircle, it is required to form a larger one, (not a Semicircle,) so that the Intersection of those two Arches shall beget, or make the Arch-Line of the Angle to hang perpendicular over its Base; as also to draw that Arch-Line of the Angle.

F I G U R E XXIII.

FIRST draw the Lines AB and CD, to represent the Walls from whence the Arches spring, and draw the Line CB, and on the Line AC describe the Semicircle AEC, and divide AC into any Number of equal Parts, from whence draw Parallel Lines to CD, to touch or come to the Arch AEC, and if those Parallels are continued out to the Line CB, they will divide it into the same Number of equal Parts, as AC is; and if from each of the Divisions of this last Line Parallels to AC are drawn, they will divide the Line AB into the same Number of equal Parts, as AC, or CB, is divided into. This being done, continue AC to I, so that AI be equal to Ef, and continue DB to K, so that KB be likewise equal to Ef, or AI, and draw the Line IK. Moreover, at the Points C and B raise the Perpendiculars CN and BO to CB, each of the same Length as Ef, or AI, or BK, and draw the Line NO. Lastly, from the Divisions of AB, draw Parallels to AI, (that is, continue the Parallels drawn from the Divisions of the Line CB to the Line IK,) and from the Divisions of CB Parallels to CN. Then set off the Heights or Lengths of each of the Parallels in the Semicircle AEC, upon the Correspondent Parallels to AI and CN, and stick in Nails whereat they terminate; and if a Lath be bent round them, so as to touch them all, and a Pencil be moved round the Edge of it, the Arches AHB and BMI will be found; which was required to be done.

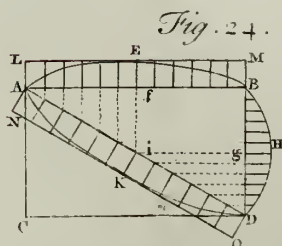
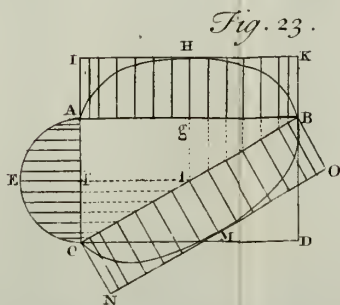
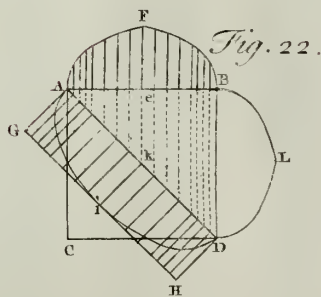
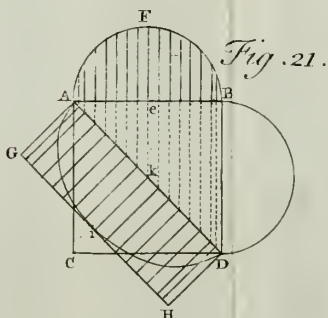
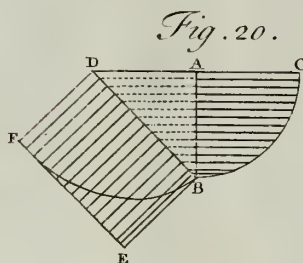
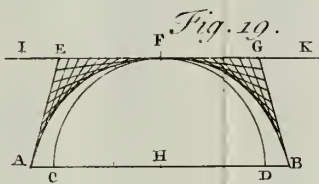
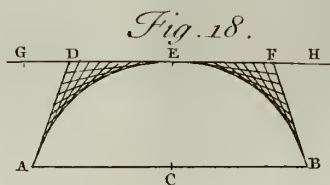
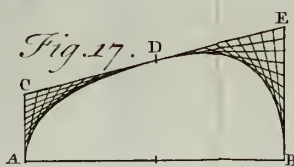
Note, The Prick'd Lines in this, and all other Examples of this Kind, shew that one Parallel Line has a Relation with the other. For Example: The Lines fE , gh , and IM , are all equal to one another; so that if the three Arches AHB , AEC , and CMB , were raised perpendicularly upon the Lines AB , AC , and CB , and a Line drawn from H to M , and another from M to E ; then would the Line HM be parallel to, and directly over the prick'd Line fg . In like Manner, the Line EM would be parallel to, and directly over the prick'd Line ft . Understand the same of the other Parallels and prick'd Lines in this Figure, and any others of the like Nature.

P R O B L E M XXIV.

If the lesser Arch of an Irregular Groin be a Scheme-Arch, it is required to form the greater, (which will not be Circular,) so that the Intersection of these two Arches shall beget the Arch-Line of the Angle to hang perpendicularly over its Base, and to draw this Arch-Line of the Angle.

F I G U R E XXIV.

FIRST draw the Lines AB and CD , to represent the Walls from whence the Arches spring, and upon BD describe the given Scheme-Arch BHD , and divide BD into any Number of equal Parts, thro' the Divisions of which you must draw Parallels to the Arch, as above; and when the Line AD is drawn, continue those Parallels to it, and they will divide it into the same Number of equal Parts as AB is; and from each of these last Divisions draw Parallels to divide the Line AB into the same Number of equal Parts as BD , or AD , is divided into. This being done, at the Point A draw the Lines AL and AN perpendicular to AB and AD , each of the same Length as gH ; and from the Points B and D , the Lines BM and DO , and draw the Lines LM and NO . Lastly, if Parallels are drawn from
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the Divisions of A B and A D, after the very same Way as in the last Problem, and you lay off upon them the Parallels in the Scheme-Arch B H D, and proceed according to the Directions above, you will form the Arches A E B and A K D, required.

Note; You need not make use of the Diagonal Arch A K D, in the making of the Centres for Bricklayers or Mafons to turn their Arches upon; because the two Arches A E B and B H D do intersect each other, and make the Angle or Edge of the Groin hang perpendicularly over its Base; and therefore the Use thereof is only in the framing of Ceilings, or the like, being in the Nature of a Hip or Valley.

The End of PLATE III.

P R O B L E M XXV.

Having one Centre given for an unequal-sided Groin, to form the other, so that the Intersection thereof shall produce the Angle, or Mitre-Arch, to hang perpendicularly over its Base: And, moreover, to draw the Curve thereof.

F I G U R E XXV.

DR A W the Lines A B and B D, and D C and C A, each ^{un}equal to one another, to represent the Walls from whence the Arches spring, and on the Line A B describe the given Arch A F B. This being done, divide the Line A B into any Number of equal Parts, from whence raise Perpendiculars to A B to touch the Arch A F B, and draw the Diagonal Lines A D and C B. Then take the Line E F, and set it perpendicular to the Lines A C, A D, C D, C B, B D, from A to O, from A to I, from C to P, from C to S, from C to L, from D to K, from D to T, from D to V, and from B to M, and from B to Z, and draw the straight Lines O P, I K, S T, L M, and Z V. Now

Now divide the Base Lines BD, DC, CA, AD, and BC, each into the same Number of equal Parts as AB is divided into, and from the Points of Division draw Parallel Lines to touch the Lines OP, ST, VZ, LM, and IK. Then take the Lengths of the Perpendiculars to AB, drawn to touch the given Arch AFB, and set them off in the correspondent Parallels, drawn from the Points of Division of the several Bases upwards, and the Arches ByD, DvC, CqA, AbD, and CnB, will be described as in the foregoing Examples, (*Figure XXIII, & XXIV.*) whose Heights xy , wv , rq , gh , and gn , are each equal to EF, as likewise all the other correspondent Heights, from the Bases, to the Curves that are formed.

P R O B L E M XXVI.

The Arch-Line of a large Ceiling, or Vault, supposed to be Semicircular being given: How to form the Curve of a lesser Arch, that shall intersect the Side thereof, to give way for Doors or Windows, so that their Intersection shall produce the Groin to hang perpendicularly over its Base; as also to form the Curve-Line thereof.

F I G U R E XXVI.

FIRST draw the Lines AB, BD, DC, and CA, to represent the Walls from whence the Arches spring, and describe the two given Semicircular Arches OAB, CLD, and in the Line BD set off the Spand of the Intersecting Arch from v to t . This being done, set off the Height you design to rise the lesser Arch vzt from g in the Line AOB, perpendicularly to touch the Arch in b , and from v to R, and t to u , and draw the Line Ru, which halve in the Point z , and draw the Line zy , parallel to vR , or tv . Then strain a Line, or lay a straight Rule from

from b thro' g , towards x ; as also from z thro' y , towards x , and these two Lines will cut one another at x , from whence to the Points v and t draw the Lines xv and xt . Now set off gb perpendicular to xt from x to w , and from t to s , and draw the Line sm , and divide gB into any Number of equal Parts at pleasure, from the Divisions of which draw Perpendiculars to gB , to touch the Arch BOA between the Points B and b , and divide vy and yt , the Halves of the Base vt , each into the same Number of equal Parts, as gB is divided into; as likewise the Base xt , and from the Points of Division draw parallel Lines to touch the Lines uR and sm . This being done, take the Lengths of the Lines that were drawn from the Points of Division of Bg , perpendicularly to touch the Part Bb of the Arch BOA, and set them off in the correspondent Parallels from yv to zR , and from yt to zu ; as likewise from xt to ws . Then, if at the Extent of each Line as you set it off in the Parallels, you stick in Nails, as in the foregoing Examples, and bend a thin Ruler about them, you will describe the sought Arches vzt and wt , whereof vzt is the true Intersecting Arch, and wt the Curve Line of the Groin that is correspondent thereto.

After the very same Manner the Arches kmz and kp are drawn.

P R O B L E M XXVII.

The Arch-Line of a Ceiling, or Vault, supposed to be an Ellipsis, being given, how to form the Curve of a lesser Arch, to give way for Doors, or Windows, that shall intersect the Side thereof so, that their Intersection shall produce the Groin, or Mitre-Arch, to hang perpendicularly; as also to form the Arch-Line thereof.

F I G U R E XXVII.

FIRST describe the Lines AB, BD, DC, and CA, representing the Walls from whence the Arches
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spring,

spring, and in the Line AC set the Spand of the Arch kz , and on the Lines AB and CD describe the Semi-Ellipses AOB, CLD, representing the given Arches. Then take the Height you design to rise the lesser Arch, and set it perpendicularly from the Line AB, as at e , to touch the Arch AB at f : Also set the same Height from k to i , and from z to q , and draw the Line iq . This being done, draw a Right-Line at pleasure from f thro' e , towards o , and another from m thro' n , cutting it in the Point o , from which draw the Lines ok , oz , and take mn , the Height of the lesser Arch, and set it perpendicularly from o to p , and from k to l , and draw the Line pl . Then divide Ae into any Number of equal Parts at pleasure, from the Divisions of which draw Perpendiculars to AB, to touch the Arch AOB, and divide the Lines zq , nk , and ok , as in the last Problem you did the Lines vy , yt , and xt , and draw Parallels as there. Now, if you take the Lengths of the Lines that were drawn from the Points of Division of Ae , perpendicularly to touch the Part Af of the Curve AOB, and set them off in the correspondent Parallels; from kz towards iq , and from ok towards lp , and at the Extent of each Line stick in Nails, as in the foregoing Examples, you may describe the sought Arches kmz , and kp .

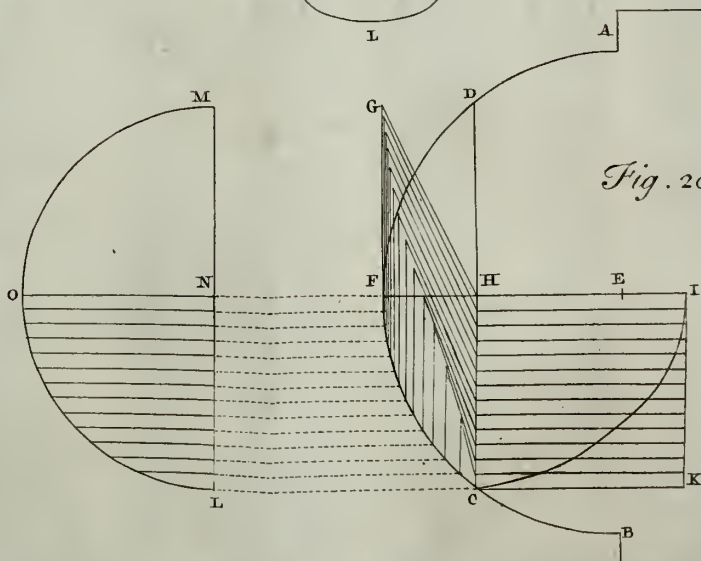
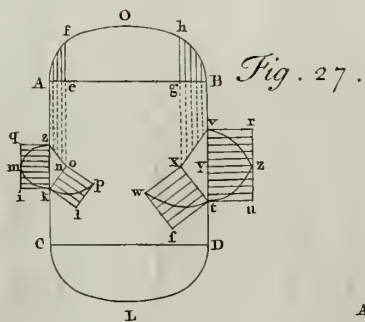
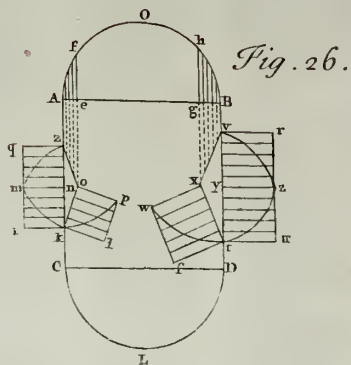
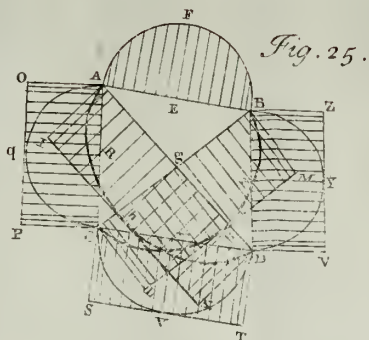
After the very same Manner may the Arches vzt and tw be drawn.

P R O B L E M XXVIII.

The Arch of a round Tower, or any other Circular Building, being given, wherein a semicircular Window is to stand; how to form a Centre so, that the Mason, or Bricklayer, shall twin their Arches thereon without crippling them.

F I G U R E XXVIII.

FIRST draw the Arch AFB from the Centre E, to represent the Arch-Line of the Wall, and set the Width of the Window from C to D, which halve at H, and



and draw the Line LM, which halve at N; from whence describe the Semicircle L O M. This being done, divide the Semidiameter LN into any Number of equal Parts, from the Divisions of which draw parallel Lines to OL, the Arch of the Quadrant, which Parallels continue out to divide the Arch FC into the same Number of Parts as LN is, and from the Points of Division in the Arch FC draw Perpendiculars to the Parallels, each equal in Length to the correspondent Parallel of the Quadrant LO; and from the Points of the Divisions of the Line HC, (made by continuing out of each of the aforesaid Parallels,) draw Right-Lines to the extreme Points of the aforesaid Perpendiculars, as from G to H. This being done, if the Line GH be laid off in the Parallel ON continu'd out from H to I, and the rest of these Lines last drawn be laid off in the respective Continuations of the Parallels, the extreme Points of these Lines being joined, will form the Curve CI, which, when set in its due Position will hang perpendicularly over the Arch CF, having its Points co-inciding with the Extremities of the Perpendiculars drawn from the Extremities of the Perpendiculars drawn from the Divisions of the Arch CF.



S E C T I O N III.

Of the Formation of Niches.

P R O B L E M XIX.

How to form a Semicircular Nich with Ribs, as is usual when it is to be plaster'd.

F I G U R E XXIX.

FIRST describe the Semicircular Plate ACB, as also the Semicircular Front-Rib ADB, equal to it, and fix the Plate ACB level in the Place where it is to continue, and

and upon it set the Front-Rib ADB perpendicular on AB. This being done, describe the Quandrantal Ribs DC, DE, DF, DG, and DH, each equal to AD or BD, and place them about eight Inches and a half from one another on the Plate ACB, as at C, E, F, G, and H, so as to meet in one Point at D on the Crown of the Front-Rib ADB; and thus is one half of the Work finished. And after the same Manner may the other be done.

P R O B L E M X X X.

How to form a Semicircular Nich by the Thicknesses of Boards, or Planks, and to find the Bevel of each Thickness.

F I G U R E X X X.

FIRST describe the Semicircle on the Front of the Nich ADB, and divide the Heighth *eD* into equal Parts, according to the Thickness, of the Board or Plank, of which you design to make the Nich. Then describe the Thicknesses from whence the Bevels are taken, and draw Lines equal to the prick'd Lines in the Example. This being done, take the prick'd Line 12 in your Compasses, and on the under Side of the Board, or Plank, of which you design to make the first Thickness, describe a Semicircle from 1 equal to ADB, the Semidiameter being equal to the prick'd Line 12. Then strike a square Stroke on the Edge from 1, to find the Centre for the Semicircle on the upper Side of the first Thickness, as at 3, and take the prick'd Line 34 in your Compasses, setting one Foot in 3, with the other draw a Semicircle on the upper Side of the first Thickness, whose Semidiameter is equal to the prick'd Line 34. Having an Arch described on each Side of the first Thickness, with a narrow Turning-Saw cut directly thro' the Arch-Line on each Side the Board, or Plank, and so you will have the true Bevel and Curve thereof.

Now, to make the second Thickness, describe the Semicircle last drawn on the under Side thereof, as you did on the

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the upper Side of the first Thickness, 34 being also the Semidiameter equal to it. Then strike a square Stroke from 3 on the Edge of the Board, or Plank, to find the Centre for the Semicircle on the upper Side of this second Thickness, and take the prick'd Line 56 in your Compasses, and setting one Foot in 5, with the other describe a Semicircle on the upper Side of the second Thickness, having its Semidiameter equal to 56. Then with a Turning-Saw cut thro' the two Arches in the first Thickness, and the Arch-Line and Bevel of the second Thickness will be finished.

To find the Arch-Line and Bevel of the third Thickness, you are to proceed after the same Manner as in the first and second Thickness, and so of the others.

Having your Thicknesses all ready, according to their true Arches and Bevels, set them in good and well-made Glue, letting it stand till it be quite dry, and with a Compass Smoothing-Plane, a little quicker than the Arch of the Work, plane the Inside thereof till it be fit for the Purpose design'd.

P R O B L E M XXXI.

How to form an Elliptical Nich, with Ribs for Plastering.

F I G U R E XXXII, & XXXIII.

FIRST describe the two Figures 32 and 33, knm being a Semi-Ellipsis, representing the Plate whereon the Ribs stand, and being equal to ADB or AeB . The prick'd Lines ln , lo , lp , lq , lR , and lm represent the Base Lines of the Ribs eD , fD , gD , bD , iD , and BD ; so likewise do the Lines st , su , sw , sx , and sy , and the Perpendiculars at , bu , cv , dw , ex , and fy , do represent the Rising of the Ribs eD , fD , gD , bD , iD , and bD , which is equal in Length to CD ; observing that within those Lines the different Arch of each Rib is to be described, viz. the Arch sa is a Quadrant of a Circle, having t for its Centre,

H

and

and is equal to the Arch of the Rib eD . The Lines us , sz equal to zb , bu are the Semi-tranverse and Conjugate Axes of a Semi-Ellipsis, whose Arch sb is equal to the Arch of the Rib fD , which may be struck either with a Trammel, or by the Intersection of Lines. Moreover, the Lines sz , sv , equal to vc , cz , are the Semi-tranverse and Conjugate Axes of a Semi-Ellipsis, whose Arch is equal to the Arch of the Rib gD , and so of the rest.

Now having the Ribs all ready, set the Front-Rib ADB perpendicular on the Plate AeB , as at AB , and fix the Feet of the short Ribs on the Plate AeB , as at e, f, g, b, i , which correspond with the Points n, o, p, q, r , and their Points a, b, c, d, e , to the Crown of the Front-Rib at D ; and thus may you finish your Work.

P R O B L E M XXXII.

How to form an Elliptical Nich by the Thickness of Boards, or Planks. (See Fig. XXXIV.)

F I G U R E XXXIV.

FIRST on a Drawing-Board, or Floor, describe (*Figure* XXXIV, XXXV, XXXVI, and XXXVII,) the Arch ABC and fgb being Semi-Ellipses equal to one another. The Arch ln is a Quadrant of a Circle, and the Arch op is a Quadrant of an Ellipsis, being the two most different Arches of the Nich. The Arch fgb represents the first Thickness, and is equal to ACD , and the perpendicular Lines mn and gp are equal to eB , and the Base Line lm is equal to ig . Moreover, the Base Line og is equal to ik , whose Arches ln, op , with their Bevels, do stand perpendicularly over ig and ik .

Now take the Board, or Plank, of which you design to make the first Thickness, and on the under Side thereof describe a Semi-Ellipsis equal to ADC , or fgb , whose Semi-tranverse Axis is equal to the prick'd Line 12 , and Semi-conjugate to 13 : Then at 1 strike a square Stroke on the Edge of the Board, or Plank, to find the Middle of the

the

Fig. 29.

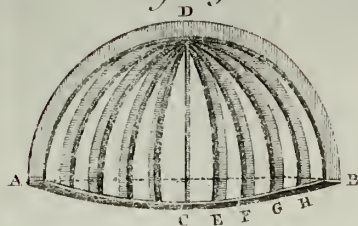


Fig. 30.

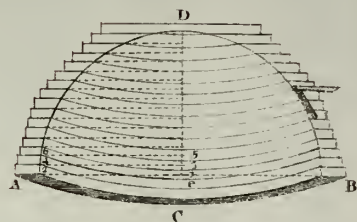


Fig. 31.

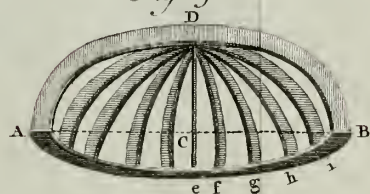


Fig. 34.

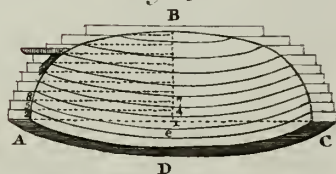


Fig. 32.

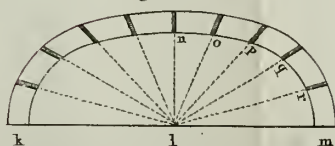


Fig. 35.

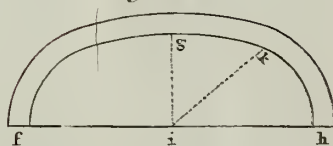


Fig. 33.

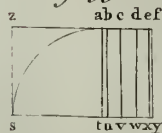
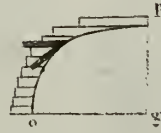


Fig. 36.



Fig. 37.



the Base to the Elliptick Arch on the upper Side of the first Thickness at 4; whose Semi-tranverse is equal to the prick'd Line 45, and Semi-conjugate equal to the prick'd Line 46, by Means of which describe an Elliptick Arch on the upper Side of the first Thickness. Then by Means of these two Elliptick Arches, described upon the upper and under Side of the Piece, with a Turning-Saw, saw out the Curve and Bevels of the first Thickness.

To find the Arch and Bevels of the second Thickness on the under Side of the Board, or Plank, of which you design to make it, describe an Elliptick Arch equal to that on the upper Side of the first Thickness, whose Semi-tranverse and Semi-conjugate Axes are also equal to the prick'd Lines 45 and 46. Then from 4 strike a square Stroke on the Edge, to find the Middle of the Base Line to the Arch on the upper Side of the second Thickness, whose Semi-tranverse is equal to the prick'd Line 78, and Semi-conjugate equal to the prick'd Line 79, and with a Turning-Saw, as before, saw out the Arch and Bevels thereof; and so of the rest.



S E C T I O N IV.

Of the Formation of Twisted Rails.

P R O B L E M. XXXIII.

How to find the Raking Arch, or Mold, for the Hand-Rail to a Circular Pair of Stairs, in such Manner that it shall stand perpendicularly over its Base, or Arch of the Well-Hole.

F I G U R E XXXVIII.

FIRST describe a Circle equal to the Breadth of the Well-Hole, whose Diameter is UW; as also another from the same Centre, whose Diameter is AG, to represent

represent the Plan of the Rail, and divide the Circumference of the greater Circle into the same Number of equal Parts as you would have Steps once round the Circle.

This being done, take the Back, or Rake, of the Bracket equal to CF in your Compasses, and setting one Foot in A, with the other strike the Arch *b*: Also take the Height of one Step, as AC, *Figure XL*, and setting one Foot in B, with the other strike the Arch *i*; and when this is done, take the Distance from A to *b* in your Compasses, and setting one Foot in *b*, with the other strike the Arch *k*, and take the Height of two Steps, and with one Foot in C draw the Arch *l*, to intersect the Arch *k*, and so on. The Intersecting Points of the Arches *bi*, and *kl*, and *no*, and *rs*, and *tu*, are all at the same Distance from one another, and the Lines *Bb*, *Ck*, *Dn*, *Ep*, *Fr*, *Gt* being the Risings or Heights of the Steps in *Figure LX*, *Bb* being the Height of one Step, *Ck* of two, *Dn* of three, *Ep* of four, *Fr* of five, *Gt* of six. Now if these Lines are raised up perpendicular on the Circle ADG, it is evident that the Point of Intersection of the Arches *b* and *i* will stand perpendicularly over the Point B; of the Arches *k*, *l* over C; of the Arches *p* and *q*, over E; of the Arches *p* and *g*, over E; of the Arches *r* and *s* over F; and of the Arches *t* and *u*, over G. Now if Nails be struck into the intersecting Points of the said Arches, and a thin Rule be bent round them, you may describe the Arch *Abknprt* by the Edge thereof, being the Mold, to strike the Arch of the Rail with.

P R O B L E M XXXIV.

The Arch or Mold of the Rail being found, as above, how to prepare the Stuff of which the Rail is to be made, and work the Twist thereof without setting it up in its due Position.

F I G U R E XXXIX.

FIRST strike two Circles, whose Diameters are equal to UW and AG, in *Figure xxxviii*. and next consider

der into how many Pieces you glue the Rail, which in the Semicircle let be fix, as in the Example.

Now divide the Semicircle into fix equal Parts, as EF, FM, MS, SL, LD, and DR, from each of these Points of Division, draw Lines to the Centre A, as AE, AF, AM, AS, AL, AD, AR. Then from F raise FG, perpendicular to AF, and equal to the Heighth of one Step: Also at the Point M raise MN, perpendicular to AM, equal to the Heighth of two Steps; and in like Manner at the Points S, L, D, and R, raise the Perpendiculars ST, LY, DE, and RL, respectively equal in Length to the Heighth of three, four, five, and six Steps. Then draw a Line from G to R, parallel and equal to AF; as also another from N to *y*, parallel and equal to AM; another from T to W, parallel and equal SA; another from Y to B, parallel and equal to LA; another from E to H, parallel and equal to DA; and another from L to P, parallel and equal to RA. From the Point A draw the Line AB, perpendicular to AE, and equal to the Heighth of one Step; also at the Points R, *y*, W, B, H, P, draw the Lines RL, YZ, WX, BC, HI, PO, all equal to the Heighth of one Step, and respectively perpendicular to RG, *y*N, TW, YB, EH, LP, and draw the Hypothenufes EB, LG, ZN, TX, YC, EI, LO.

This being done, set off the Width of the Rail from E to *d*, G to *i*, N to *o*, T to *u*, Y to *a*, E to *f*, and L to *m*; and set the Stem of a Square on the Line EB, till the Blade thereof touches the Point *d*, and draw the Line *cd*. Moreover, set a Square on the Line GL, and where it cuts the Line RG, as in the Point *i*, draw the Line *hi*; and in like Manner draw the Lines *po*, *un*, *za*, *gf*, and *nm*. Then the Angles *Edc*, *Gih*, *Npo*, &c. and the rest of the little black Spaces, as you see in the Figure, do represent the Twisting of each Piece, and what must be taken off from the Back at the lower End, to make the Twist of the Rails. The Lines being drawn, you are next to consider after what Manner they are to be applied in the working of the Rail.

Take the Piece of Timber, of which you design to make the first Length, which is represented in *Figure XLI*, and plane one Side thereof straight, and cut it to its Bevels

ac, *bd*, answering to *DRA* and *RDA*, *Figure xxxix*, and both Ends thereof being also cut to the Raking Joint of the Rail, proceed thus: Take that Part of the Raking Arch in *Figure xxxviii*, which answers to the first Length of the Rail, as *Ah* in the Arch *Az*, and lay it on the upper Side of *Figure xli*, from *l* to *h*, and strike the Arch *lh*; then take *Ec*, equal to *Gh* or *Np*, in *Figure xxxix*, and set it on the Line *bd* from *b* to *m*, (*Figure xli*,) and strike a square Stroke at Pleasure from *m* to *g*; also take *cd* equal to *hi*, or *po*, &c. and set it on the Line from *m* to *g*, and draw the Line *hg*, which represents the Back of the Rail when it is work'd, and is equal to *Ed*, or *Gi*, or *No*, &c. This being done, represent the lower End of the Rail *hgki*, at Right-Angles to *hg*; as also the upper End *lcdn* at Right-Angles to *lc*, and baste out the inward Arch *cm* square from the upper Side *abcd*, as *mg*; and take a thin Lath, and bend it close to the Side thereof from *c* to *g*, whereon strike a Line along the Edge of the Lath, and so the Lines *lh* and *cg* are your Guides in backing the Rail: Which, when done, turn the Piece upside down, and with the Mold strike an Arch equal to *lh* from *a* to *k*, and baste out the Side to the Lines *lh* and *ok*. Then you have one Side, and the Back squar'd, which is the greatest Difficulty in the Formation of a Twist-ed Rail, because the two other Sides are found by gauging from them.

Note, If the Triangles in *Figure xxxix*, and Lines whereon they stand be supposed to be raised up perpendicularly, then will the Lines *AB*, *KL*, *yZ*, *WX*, *BC*, *HI*, *PO*, join to each other, and produce one Line perpendicularly over *A*, equal to seven Risings or Heighths of the Steps. But in working a Rail of this Kind, you have need of but one Triangle *ABcEd*, because they are all equal, and of but one Effect in working, they being drawn only to satisfy the Curious in the Nature of the Thing.

P R O B L E M XXXV.

How to frame the Arch, or Mold for a Hand-Rail to an Oval Pair of Stairs, so that the same shall stand perpendicularly over the Profile, or Arch of the Well-Hole.

F I G U R E XLII.

THE Arch *Akmoqsm* is found after the same Way as the Arch *Abknprt* is found in *Figure xxxviii*; and *Figure xliii* bears the same Relation to *Figure xlii*, as *Figure xxxix* does to *Figure xxxviii*, and is made thus: *a, b, c, C*, are the Centres, by means of which the Oval is made; *a* being the Centre for striking of the Part *Go* of the Oval, from whence the Lines *aG, ab, aI*, are drawn; *b* the Centre for striking the Arch *nz*, from whence are drawn the Lines *bz, bm, and bn*; and *C* is the Centre for drawing the Arch *gu*, from whence the Lines *cg, cA, cu* are drawn, which Lines shew where the Rail must answer square.

Now to *ab* raise a Perpendicular from *b* to *I*, equal to the Rising or Heighth of one Step of the Stairs, and from *O* to *aO* raise a Perpendicular to *P*; raise another to *cu*, from *u* to *V*; another from *cA*, from *A* to *Z*; another to *cg*, from *g* to *b*; another to *Cn*, from *n* to *o*; another to *bt*, from *t* to *u*; and another to *ab*, from *z* to *1*. Then from *I* draw the Line *Im*, equal and parallel to *ab*; from *P* the Line *PS*, equal and parallel to *ao*; from *V* the Line *VZ*, equal and parallel to *uc*; from *B* the Line *BF*, equal and parallel to *CA*; from *H* the Line *HL*, equal and parallel to *gc*; from *o* the Line *oz*, equal and parallel to *ac*; from *u* the Line *ux*, equal and parallel to *tb*; and from *1* the Line *14*, equal and parallel to *ab*. This being done, at the Points *a, m, S, Z, F, L, z, x, 4*, to the Lines *ab, Im, PS, VZ, BF, HL, oz, ux, 14*, raise the Perpendiculars *aD, mn, ST, ZY, EF, ML, Sz, yx, 45*, each equal in Length to the Heighth of one Step, and draw the Hypothenusal

then useal Lines DG, *nI*, TP, YV, EB, MH, *os*, *uy*, 15, and set off the Width of the Rail from G to *e*, I to *l*, P to *z*, V to *x*, B to *d*, H to *k*, *o* to *p*, *u* to *v*, and 1 to 3, and set the Stem of a Square on the Line GD till the Blade cuts the Point *e*, and draw the Line *ef*. After the same Manner set the Stem of a Square on the Line *nI*, till the Blade touches *l*, and draw the Line *kl*, and so draw the other Lines *qz*, *wx*, *cd*, *ik*, *qp*, *wv*, 23, as in the last Problem.

Note, If the Triangles in this Figure were raised up perpendicularly, then would *aD*, *mn*, ST, stand perpendicularly over *a*, and *zY*, FE, ML, perpendicularly over the Point C; and *zs*, *yx*, 45, perpendicularly over the Point *b*; so that in this Figure you will have Occasion for two different Triangles, because there are two different Sweeps that are the Cause of two different Twists in the Rail; and so the the Triangles *aGD*, VZY, are enough for squaring of this Rail; and always observe, that as many different Sweeps as are contain'd in the Ground Work of the Rail, there are so many different Twists, and consequently so many different Triangles, because the Twist is found by Means of them.

P R O B L E M XXXVI.

How to form the Arch or Mold to the Hand-Rail of a Pair of Stairs that sweep two Steps, so as to stand perpendicularly over its Ground, and the Manner of squaring the same, without setting it up in its Position.

F I G U R E XLIV, XLV, XLVI, XLVII.

FIRST draw *Figure* XLIV, to represent the Ground-Work of the Rail, whose Arch GC consists of two different Arches, one whereof is a Quarter of a Circle, and the other a Quarter of an Oval. AB (equal to AC, equal to CD, equal to BD) is equal to one Third of a Step, and D is the Centre to the Arch CB: Also BF is equal to two Thirds of a Step, and FG is equal to one Step and two Thirds,

Fig. 38.

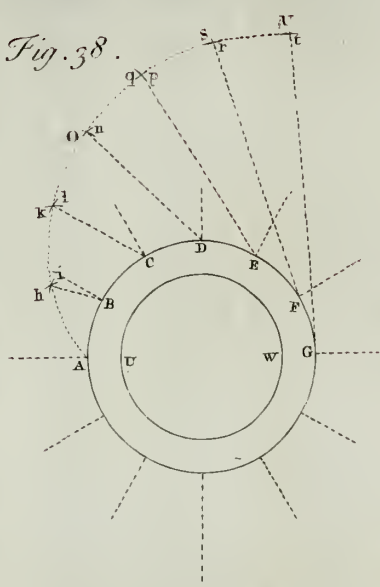


Fig. 39.

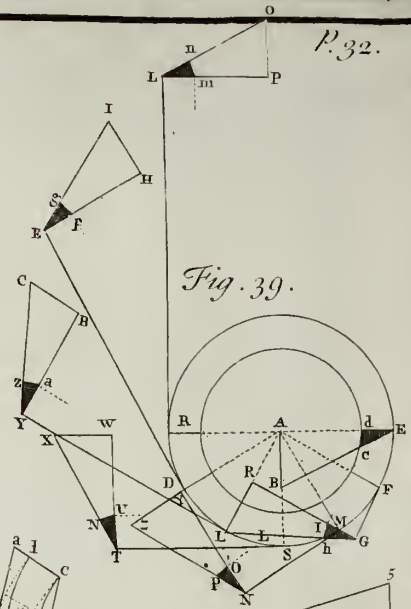


Fig. 42.

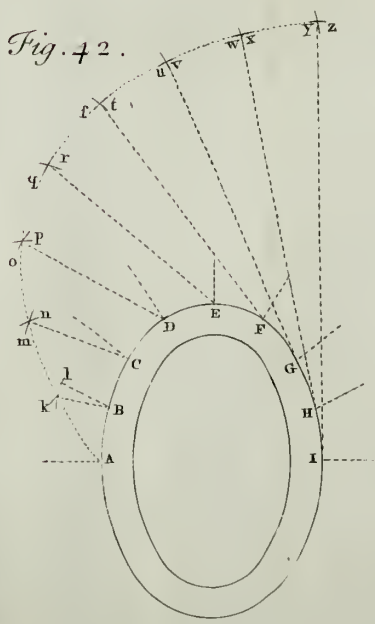


Fig. 41.

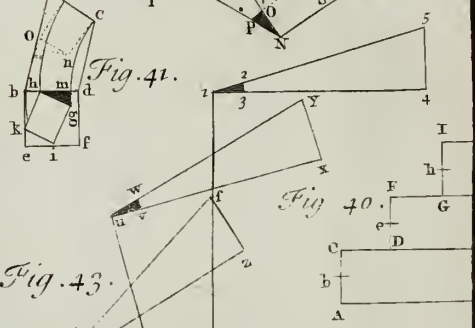
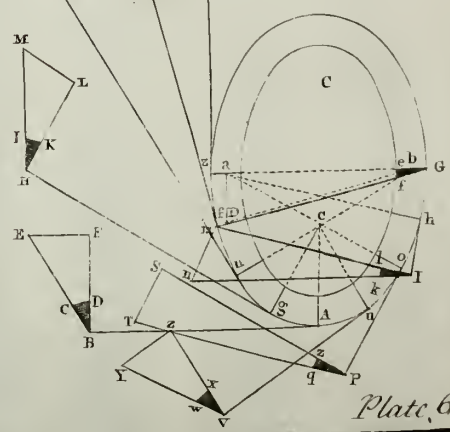


Fig. 43.



Thirds, by Means of which, and BF, is the Arch GB described. GK represents the straight Part of the Rail to one Step, and the Arch HD is drawn by gauging from the Arch GC, that is, it is drawn parallel to it; and the straight Part IH is found by gauging from KG, or is drawn parallel to it.

Figure XLV. shews the Manner of drawing the Rake or Arch of the Rail, which is done thus: Draw IL equal to GK of *Figure XLIV.* and represent the Tread of the Steps, as before, by prick'd Lines. Then divide that Part of the Ground-Work of the Rail that belongs to each Step into any Number of equal Parts, as AF into 5, and FK into 4. This being done, draw AB, BC, CD, in *Figure XLVI.* to represent the Rising and Tread of the Steps; and continue out the Line CB, at Pleasure, towards T, in which set the five Divisions on the Ground of the Rail to the first Step, FE, of *Figure XLV.* being equal to CI, of *Figure XLVI.* also ED equal to *ik*, DC to *kl*, CB to *lu*, and BA to *uT*. Then will the Line CT, in *Figure XLVI.* be equal to the Arch AF of *Figure XLV.* draw the Line DT. Then is the Triangle CDT the Bracket to the first Step, according to the Sweep of the Rail; and as TC is the Length of the Ground to the first Step, so is TD the Length of the Rail answering to it. Then from the Points *i*, *k*, *l*, *u*, raise the Perpendiculars *iP*, *kQ*, *lZ*, *uS*, to CT, and take the four Divisions on the second Step, and set them in the Line CT, from C to B, and draw the Line BD; and then is BC the Length of the Ground to the second Step, and BD the Length of the Rail answering to it. Draw Lines through these Divisions, as from F to *m*, G to *n*, and H to *o*, perpendicular to CB; and so your Perpendiculars are found, according to the Compass-Brackets of each Step, and may be pieced thus.

In *Figure XLVI.* take TS in your Compasses, and with that Distance, setting one Foot in A, in *Figure XLV.* strike the Arch *m*, and take Su between your Compasses, and with one Foot in B strike another Arch to intersect the Arch *m*. Again, take SZ, or ST, in your Compasses, and with one Foot in the Intersection of the Arch *m*, and this latter Arch, describe the Arch *n*; and take lZ in your Compasses, and with one Foot in C, describe an Arch to inter-

fect the Arch n ; and thus proceed on, so that zq be equal to no , QP to op , PD to pq , qz to Bo , zs to on , st to hm , and tu to mD ; as also kQ to Do , iP to Ep , CD to qF , Ho to Gz , Gn to HS , Fm to It , ED to Ku , LW to three Times AB . The Points $n, o, p, q, r, s, t, u, v, W$, being found by the Interfection of Arches, as above, stick a Nail into each Point, and bend a thin Rule about the Nails, till it touches them all, then with a Pencil describe an Arch round the Edge thereof, which will be the Arch AW , being that of the Rail to work by.

Figure XLVII. shews the Manner of squaring the Rail, which is thus: First describe AF , the Square, or Ground of the Rail, being the same as that of *Figure XLIV*, and find the Centers to answer to the different Arches of the Ground; from whence draw prick'd Lines to the Places where you design to join the Rail, as from G to B , from G to C , from H to E , and from H to d . Because the first Step is to be joined in three equal Pieces, you must take one Third of the Rising or Heighth of the Step, and set it from B to I , perpendicular to BG , and draw the Line MI , parallel and equal to GB . Now from M to n draw a Perpendicular to MI , to rise so much as the Rail rakes over, which is one Third of the Rising or Heighth of the Step, because that Part of the Rail is one Third of the Length on the first Step, and draw the Line In , by which Means we shall have the first Triangle IMn . Then from the Point C draw Cq , perpendicular to GC , and equal to two Thirds of the Heighth of one Step, and draw the Line qz , equal and parallel to CG , and from z raise a Perpendicular zs to zq , equal to one Third of the Heighth of one Step, and draw the Line qs , and you will have a second Triangle. Again, from d draw $d'T$, perpendicular to Hd , and equal to the Heighth of one Step, and draw the Line TW equal and parallel to Hd ; and from W erect the Line WX , perpendicular to WT , and equal to the Heighth of one Step, because that Part of the Rail over the second Step will be one Piece, therefore the Triangle must rise one Heighth of the Step, and draw the Line TX , and so you will have a third Triangle WXT . This being done, from I , in the Line IM , set off Ik , equal to the Width of the Rail; also set off the same from q to o , and T to u , and setting

setting the Stem of a Square on the Hypothenuſal Line, ſo that the Blade thereof touches the Point *k*, draw the Line *kl*; and in the like Manner draw the Lines *po*, *uv*; and then the little Triangles *Ik*, *qop*, *Tuv*, do represent what muſt be taken off from the lower End of each Piece, to bring the Rail to its true Twiſt.

P R O B L E M XXXVII.

How to form the Arch or Mold of the Hand-Rail of a Pair of Stairs that ſweeps two Steps quicker than in the foregoing Examples.

FIGURE XLVIII, XLIX, L, LI.

FIRST deſcribe *Figure XLVIII*, representing the Ground or Plan of the Rail where *AE* is equal in Length to the Height of one Step, and *AC* and *AB* are the Halves thereof, and *D* is the Centre to the Arch *FCB*, which is greater than a Quadrant. *BG* is fix Sevenths of the Width of a Step, and *GH* is one Step and two Thirds of one, and from theſe Lines the Arch *HB* is made.

Figure XLIX. represents the Ground and Raking Arches of the Rail, whereof the Arch *AM* is equal to the Arch *FHI*, of *Figure XLVIII*. and the Raking Arch thereof is found by the ſame Means, and bears the ſame Proportion to *Figure LI*. as the Arch *AuW* in *Figure XLV*. does to *Figure XLVI*. and the ſeveral Lines are equal to one another, viz. *AB*, in *Figure XLIX*. is equal to *QP*, in *Figure LI*. *PO* is equal to *BC*, *OB* to *CD*, *Bk* to *DE*, *ki* to *EF*, *ic* to *FG*, *AH* to *GH*, *HG* to *HI*, *GF* to *IK*, and *EF* to *KL*. Moreover, *Figure XLIX*. *An* is equal to *QV*, *Figure LI*. *no* to *VU*, *op* to *UT*, *pq* to *TS*, *qz* to *SZ*, *zs* to *ZD*, *St* to *Bn*, *tu* to *nm*, *uv* to *ml*, and *vw* to *ld*. The Perpendiculars are alſo equal to one another, viz. *Bn*, in *Figure XLIX*. is equal to *PV*, *Figure LI*. *Co* to *OU*, *Dp* to *BT*, *Eq* to *kS*, *Fz* to *iZ*, *GS* to *CD*, *Ht* to *hn*, *Iu* to *Gm*, *Kv* to *Fl*, *Lw* to *ED*, and *Mx* to three Riſings of a Step. Now, as in the foregoing Examples, the Arch *GA*, which is the Ground

Ground for the Rail to the first Step in *Figure XLIX*, is equal to the Line *CQ* in *Figure LI*. likewise the Line *QD* is equal to the Arch *AF*. Again, *BC* is equal to *GL*; *BD* is equal to *Sm*, and *nm* is equal to the Rake of that Part of the Rail that stands over *FH*; and the Triangles *Clk*, *Est*, *Guv*, do represent what must be taken from the lower End of each Piece to make the true Twist.



SECTION V.

*Of Working of Arches and Niches in Stone
and Brick.*

PROBLEM XXXVIII.

*How to work a streight Arch with Stone
or Brick.*

FIGURE LIV.



FIRST draw the Line *CD* expressing the Width of the Door or Window over which the Arch is to stand, and draw the Line *AB*, of a Length at Pleasure, parallel to *CD*, and at such a Distance from it as the Front of the Arch is in Height. This being done, draw the prick'd Lines *Cf*, *Dg*, at Right Angles to the Line *CD*, and in the Line *AB* set off the Skew-Back from *f* to *E*, and from *G* to *h*, and lay a straight Rule on the Points *E*, *C*, and draw a Line downwards along the Edge thereof towards *I*; then remove that Rule, and lay it on the extreme Points *H*, *D*, and by the Edge thereof draw a Line to cut that last drawn in the Point *I*, and the Point *I* will be the Centre to which the Skew-Backs, and the Points of each Course are directed, and they may be work'd thus :

Take *IE*, or *IH*, between your Compasses, and setting one Foot in *I*, with the other strike the Arch *EH*, in which set off the Thickness of every Course, as in the Example

Fig. 44.

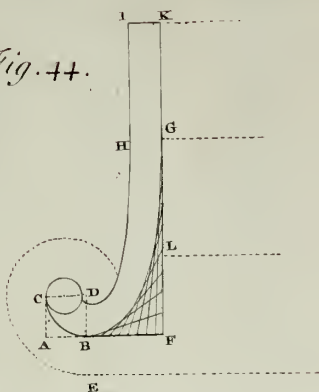


Fig. 47.

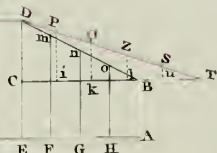
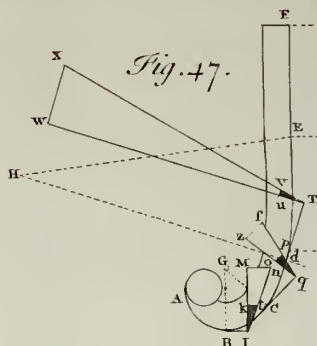


Fig. 46.

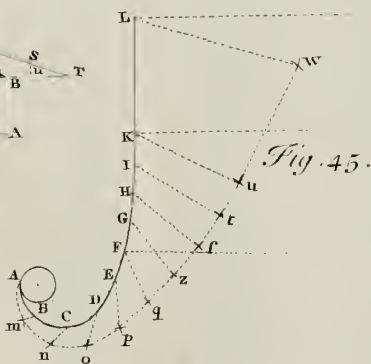


Fig. 45.

Fig. 48.

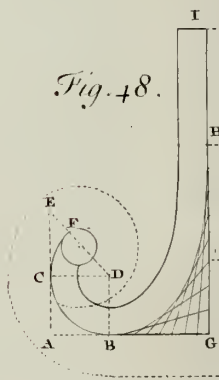


Fig. 51.

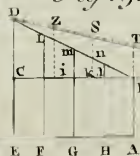


Fig. 49.

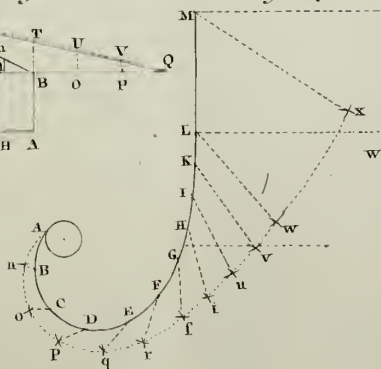
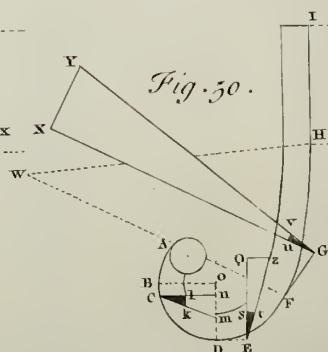
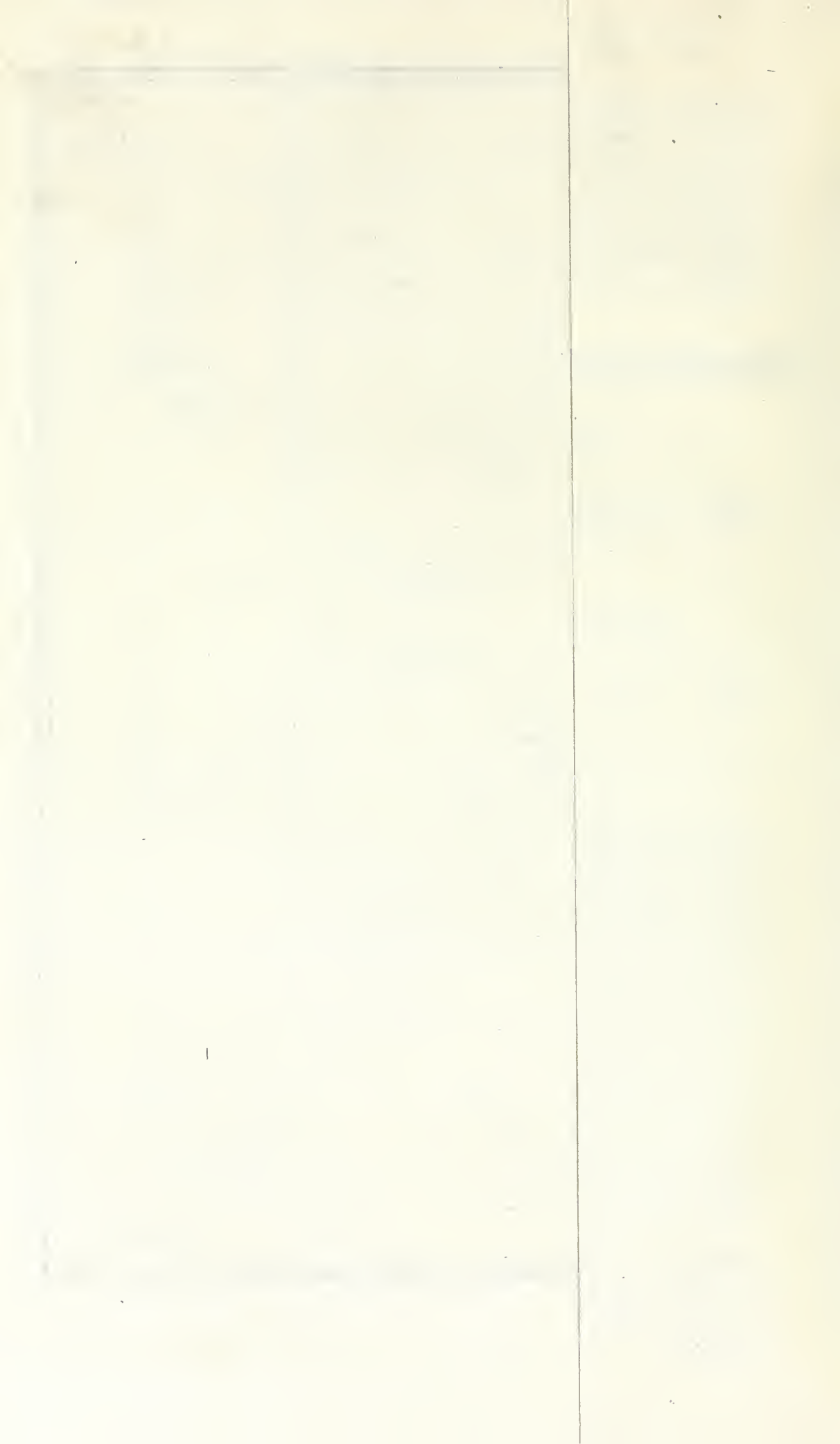


Fig. 50.





Example mark'd E 1, 12, 23, 34, 45, 56, 67, &c. This being done, lay a straight Rule from 1, in the Arch EH, to I, and along the Side thereof draw the Line 11, from the Line AB to the Line CD, which represents the first Joint; also lay your straight Rule from 2, in the Arch EH, to I, and along the Side thereof draw the Joint 22, from the Line AB to the Line CD, and you will have the second Joint; and proceeding thus you will have all the Upright Joints.

When this is done, mark the Cross Joints parallel to the Lines AB, CD, as in the Example, and they will denote the true Bevels of the Arch, according to which the Stone, or Bricks, are to be work'd.

P R O B L E M XXXIX.

How to work a Scheme-Arch with Stone or Brick.

F I G U R E LV.

FIRST draw the Line CD to represent the Width of the Door, or Window, over which the Arch is to stand, and find the Centre E by the Example of *Figure III*, according to the Heighth you have a mind to raise the Arch CD. This being done, describe the Arch CD from that Centre, and from the Point E thro' the Points C, D, draw two Right Lines EA, EB, of Lengths at Pleasure, and in them, from the Points C, D, set off the Heighth of the Front of the Arch to the Points A and B; and taking AE or AB between your Compasses, set one Foot in E, and with the other draw the Arch AB, and from E strike the Cross Joints, the upright ones being mark'd after the same Manner as those in the last Problem.

P R O B L E M XL.

*How to work a Rampant Scheme-Arch with
Brick or Stone.*

F I G U R E LVI.

FIRST draw the Line CE to represent the Width of the Door, or Window; then draw the Line CD, and proceed to find the Arch CD, according to the Directions in *Figure v.* which when describ'd, from the Points C, D, raise the Right Lines Ch, Di, perpendicular to CE, and draw the Line AB parallel to CD, and so far distant from it as you design the Height of the Front of the Arch to be, and from the Points F, g, draw a Right Line downwards towards K. This being done, in the Line AB set off the Skew-Back from the Perpendicular Ch to A, and from the Perpendicular Di to B, and laying a Ruler on the Points A, C, along the Edge thereof, draw a Line towards K, to cut the Line FK at K, which is the Centre, to which the Upright Joints must point. Then from K through D lay a straight Ruler, to cut the Line AB at the Point B, and the Skew-Back i B will be had, and describe the upper Arch Line AB, by drawing the Lines AF, FB, parallel to Cg, gD, and proceeding to find the Arch AB, as is before taught in *Figure v.* which being drawn, it must be divided into Courses according to the Thickness of the Bricks or Stones. Then if a Ruler be laid from each Point of Division to K, you will mark all the Upright Joints; and the Cross Joints must be parallel to the Arches AB and CD.

P R O B L E M XLI.

*How to work a Semi-Circular Arch in Brick,
or Stone.*

F I G U R E LVII.

FIRST draw the Base-Line AD equal to the Width of the Door, or Window, and twice the Depth of the Arch, and halve it at the Point G, from which Point set off half the Width of the Door, or Window, to B and C, and from G draw the Arches BEC, AFD, and divide AFD into Courses, as in the last Problem, and laying a straight Rule from each of the Points of Division to the Point G, you may draw the Upright Joints, and from the Centre G describe the Cross Joints parallel to the Arches BEC, AFD.

P R O B L E M XLII.

*How to work a Rampant-Semicircle with Stone,
or Brick.*

F I G U R E LVIII.

FIRST draw the Line AK, and raise KD perpendicular to it equal to the Heighth of the Ramp, and draw the Ramp-Line AD, which halve at I, and according to the Directions laid down in *Figure VII.* strike the Arch BFC.

This being done, draw the Arch-Line AED so as to be parallel to the Arch-Line BFC, and at such a Distance from it as is the Heighth of the upper Surface of the Arch, which may be describ'd either by gauging from the Arch BFC, or by finding Centres that shall answer to the two different Sweeps therein, as you may see by the Example, where the Point G is the Centre for the Arch FC, and the Point

Point H for the Arch BF. Now in the Arch-Line AED set off the Thickness of the Bricks or Stones (as they are mark'd in the Example) A 1, 12, 34, &c. and from the Divisions draw the Long or Upright Joints to point to I, by laying a straight Rule from I to 1, I to 2, I to 3, &c. The Cross Joints are struck from the Centres G, H.

P R O B L E M XLIII.

How to work an Elliptical or an Oval Arch, that rises above a Semicircle, with either Brick or Stone.

F I G U R E LIX.

FIRST describe the Arch BFD by the Rule laid down in *Problem VIII.* or by a Trammel. Then describe the Arch AGE parallel to BFD, and at such a Distance from it as you design the Height of the Arch, either by Means of a Trammel, or by the following Rule:

Draw the Line AG, and take CG in your Compasses, setting one Foot in A, with the other strike the Arch O, and taking AC in your Compasses, with one Foot in G describe the Arch *p*, and from the Intersection of these two Arches, draw a Line to *i* at Right Angles to the Line AG. This being done, deduct *ik* from the Width of the Surface of the Arch BA, or FG, or DE, and set twice the Remainder in the Line *ib* from *k* to *b*, from whence draw the Lines *Ab*, *Gb*, and divide them each into the same Number of equal Parts, and draw the intersecting Lines, which will form the Arch AG. Then you will find *il* to be equal to BA, or FG, and *kl* equal to *lb*; and so of the Arch-Line EG.

The two Arch-Lines AGE, BFD, being describ'd, the Courses on the Arch-Line AGE must be divided, as in the foregoing Examples and this, where they are figur'd E 1, 12, 23, 34, 45, 56, 67, &c. and you must find the Joint of each Course, by taking a straight Rule, and cutting it off equal to CG, which, when cut to its Length,

Fig. 54.

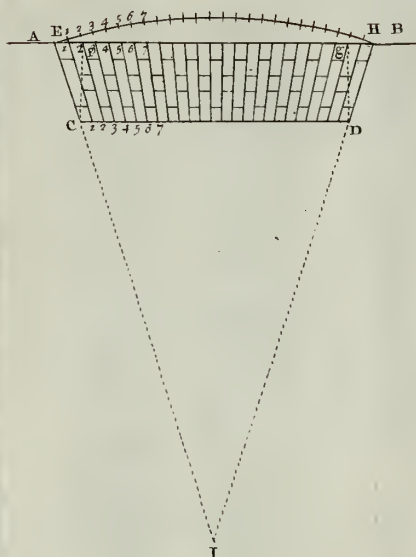


Fig. 55.

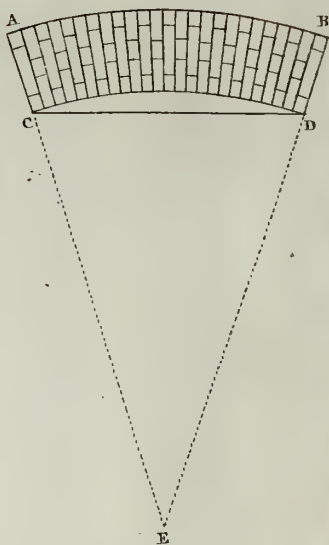


Fig. 56.

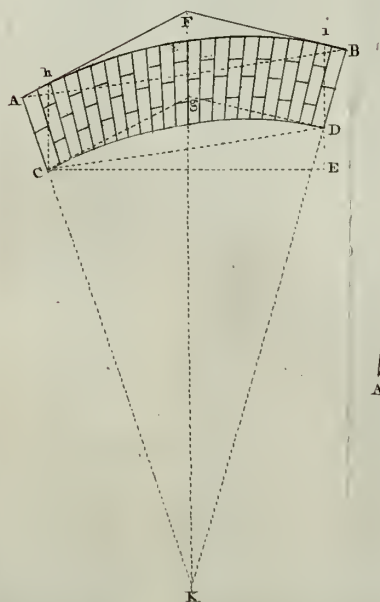
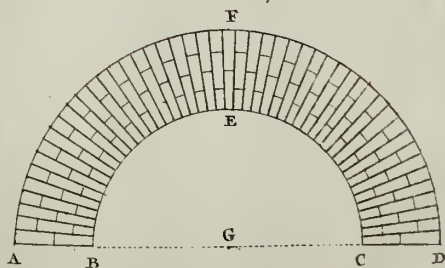
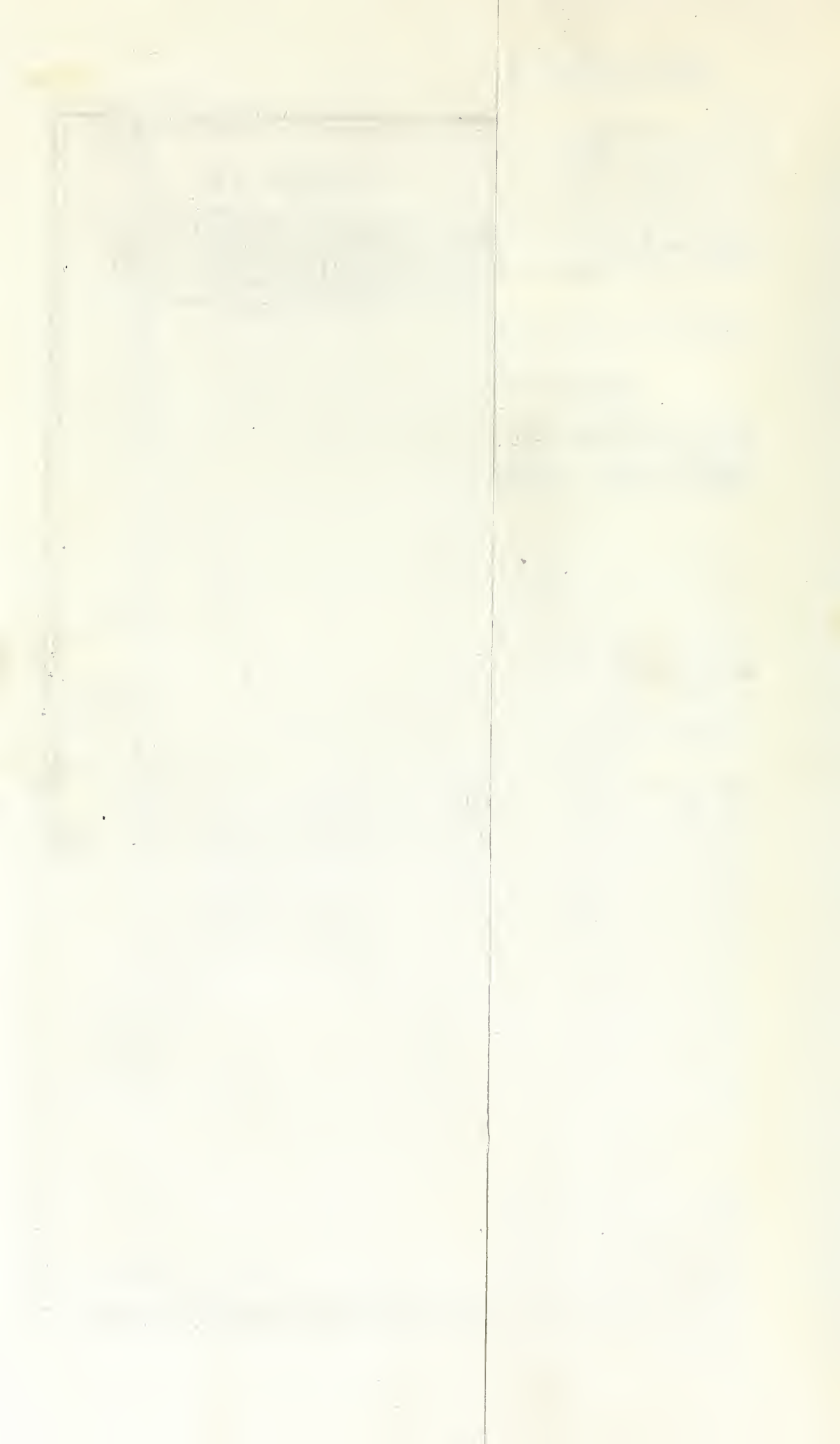


Fig. 57.





is represented by the broad Line mn . The Rule being ready, take the End n , and place the upper Corner thereof to the first Division mark'd 1, and let the upper Corner at the End m touch the Line AE , where it shall so happen, and along the Side thereof draw the first Joint; then move the upper Corner at the End n to 2, letting the upper Corner at the End m touch the Line AE , where it shall so happen, and along the Edge thereof draw the second Joint; and thus continue till you have drawn them all. And the Cross Joints must be drawn parallel to the two Arches by gauging from either of them.

P R O B L E M XLIV.

To work an Elliptical Arch, not rising so high as a Semicircle, in Stone or Brick.

F I G U R E LX.

FIRST draw the Base-Line AE , and halve it at the Point C , from which let fall a Perpendicular, of a Length at Pleasure, towards H , after which draw the Elliptical Arch BGD according to the Directions given in *Problem IX.* or *X.* and describe the Elliptical Arch AFE parallel to the Arch BGD thus: Take AB , or DE , and set it perpendicularly from G to F , and draw the Line FE , and take CF in your Compasses, and setting one Foot in E , with the other strike the Arch n : Also take CE in your Compasses, and setting one Foot in F , with the other strike the Arch o , and from the Point wherein these two Arches intersect each other, draw the Line to k at Right Angles to FE . This being done, deduct kl from AB , or DE , and set the Remainder twice in the Line from l towards the Intersection of the Arches n and o , as to i , and draw the Lines Fi , Ei , which Lines divide into any Number of equal Parts, and draw the Intersecting Lines, which will generate the Arch-Line EF parallel to the Arch-Line DC . And thus may the Arch-Line AF be generated.

Now set the Courses of the Brick, or Stone, on the Arch-Line AFE , and draw the straight Joints thus: Take a Ru-
M ler

ler, and cut it off equal to AC, or CE, which is represented by the broad Line pq , and placing the End q at 1, the first Joint, let the End p touch the Line CH, where it shall so happen, and along the Side thereof draw the first Joint; then move the End q to 2, and letting the End p touch the Line CH, where it shall so happen, and along the Side thereof draw the second Joint, and so of the others. Then strike the Cross-Joints parallel to the Arch BGD, and the Work is finish'd.

P R O B L E M XLV.

*How to work a Rampant Elliptical Arch in Brick,
or Stone.*

F I G U R E LXI.

FIRST draw the Line Au , and to Au raise a Perpendicular from the Point u to E , equal in Length to the Ramp of the Arch; and draw the Line AE , and halve it at C , and from C raise a Perpendicular towards F . This being done, describe the Arch BGD, according to the Directions laid down in *Promblem XI*, and describe the Arch AIE thus: Take BA, or DE, and set it perpendicularly from G to I , and draw the Lines AI , EI . Then take CI in your Compasses, and setting one Foot in A , with the other strike the Arch o : Also with one Foot in E , strike the Arch s with the other, and take AC , or CE , in your Compasses, and setting one Foot in I , with the other strike the Arches p and t , and from the Intersection of the Arches op , and st , draw Lines to b and l , cutting the Lines AI , IE , at the Points q and m , perpendicular to them. Now take the Line bq in your Compasses, and set it from B towards A , reaching to the Dot in AB , and take the Remainder from the Dot set A in your Compasses, and set it twice in the Cross-Line from q , towards the Intersecting Arches op , to which draw Lines from A and I . Also take lm in your Compasses, and set it from D to the Dot in the Line DE , and take the Remainder from E to the Dot, and set

it

it twice in the Cross-Line from *m* towards the Intersecting Arches *st* to *k*, and draw the Lines *Ik*, *Ek*, each of which divide into the same Number of equal Parts; as likewise the Lines drawn from the Intersection of the Arches *op* to the Points *A* and *I*: Then if Intersecting Lines are drawn, they will beget the Arch-Line *AIE* parallel to the Arch-Line *BGD*.

This being done, divide the Arch-Line *AIE* into the Courses of Brick, or Stone; and from the Divisions thereof draw the straight Joints by a Lath to the Line *CF*, as in the foregoing Example, *Fig. LX.* and mark the Cross-Joints parallel to the Arch-Line *BGD*, and the Work is finish'd.

P R O B L E M XLVI.

How to work a Gothick Arch in Stone.

F I G U R E LXII.

FIRST describe the Arch *BEC*, according to the Directions laid down in *Problem XII.* and set off the Width of the Arch *AB*, *CD*, and draw the Out-Lines *DH*, *HF*, parallel to the Lines *CG*, *GE*, wherein set the equal Divisions, and draw the Intersecting Lines, which will generate the Arch-Line *FD* parallel to *CE*. Then by *Problem III.* find a Centre answering as near as possible to the Arch *CE*, which suppose to be where the two Arches *l* and *m* meet, and this will be that towards which the Joints must point; and in like manner, the Intersection of the two Arches *i, k*, is nearly the Centre of the Arch-Lines *AF*, *BE*. This being done, set the Courses on the Arch-Line *AFD*, and then draw the Joints pointing to the Intersections of the Arches *ki* and *lm*.

P R O B L E M XLVII.

*How to work a Gothick Arch in Brick,
or Stone.*

F I G U R E LXIII.

FIRST draw the Arch BFD, according to the Directions laid down in *Figure XIII*, and set off the Width of the flat Surface of the Arch AB, DE. Then draw the Out-Lines parallel to each other, as in the foregoing Example, and describe the Arch AGE by the Intersections of Lines, which will be parallel to the Arch-Line BFD; upon which set the Courses, and draw the straight Joints pointing to C; and the Cross-Joints must be parallel to the Arches AGE, BFD, and the Work is finish'd.

P R O B L E M XLVIII.

*The Centre whereon the Arch of a Bow-Window
is turn'd being given, how to find another Centre
that shall answer parallel to it, according to the
upper Edge of the Surface of the Arch.*

F I G U R E LXIV.

FIRST describe the Arch BKC, according to the Directions laid down in *Problem xxviii*. and set the Width of the flat Surface of the Arch from B to A, and from C to D; and draw the Lines AD, BC, and halve them at F and E, from whence draw a Perpendicular of a Length at pleasure to H. Then in any convenient Place (*Figure LXV.*) draw a Line at pleasure, as from A to G, and from A draw to AG the Perpendicular AF. Then take EI, in (*Figure LXIV.*) and set it from A to B, (*Figure LXV.*) and EI from A to C. This being done, take the Semi-Diameter BE, or EC, (*Figure LXIV.*) and set it from A

to

Fig. 58.

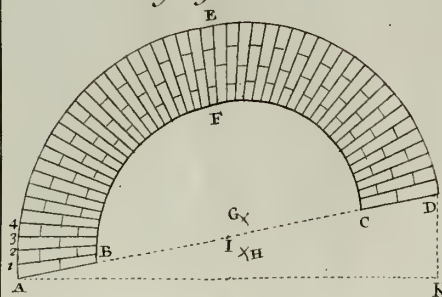


Fig. 59.

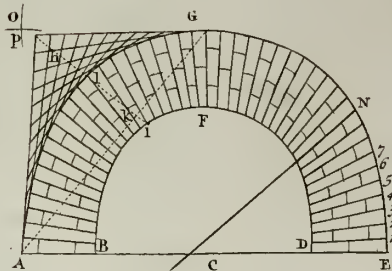


Fig. 60.

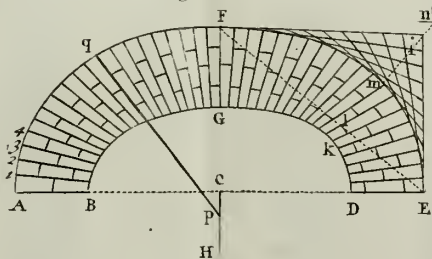


Fig. 61.

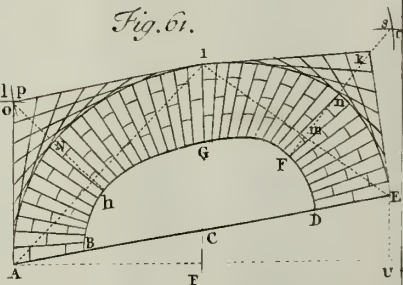


Fig. 62.

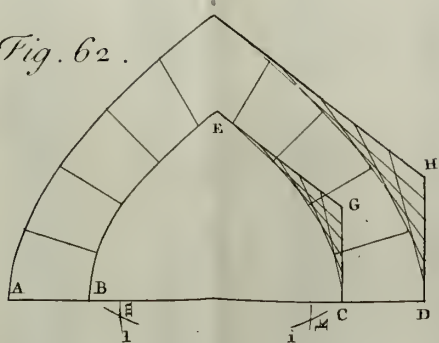
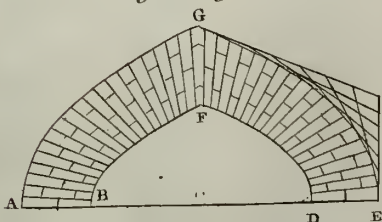


Fig. 63.



to D, (*Figure LXV.*) Also take AB, or CD, and set it from D to E, and draw the Line EC, which set in the Line EH from E to g. Again, take the Width of the flat Surface of the Arch AB, or CD, and set it in the Line EH, from K to 7, and divide the Remainder from 7 to 9 into seven equal Parts. Also divide the Arch BK into seven equal Parts. Then take K 1, in the Line EH, between your Compasses, and setting one Foot in 1, with the other strike the Arch 1 at pleasure: Then take K 2, and strike the Arch 2: Also take K 3, K 4, K 5, and K 6, severally, and strike the Arches 3, 4, 5, and 6. When this is done, open your Compasses, and divide from A to g, keeping the Points of them on those Arches, till you have gotten seven equal Distances from A to g; at the Points of which, if Nails be stuck in, and a thin Rule be bent round them, from A to g, along the Edge thereof the Arch Ag may be drawn. And in like manner may the Arch Dg be drawn.

P R O B L E M XLIX.

How to work a Nich in Brick.

F I G U R E LXVI, LXVII.

FIRST describe the Semicircular Arches AIG, and BHF, and draw the Courses pointing to the Centre, and from the Courses in the Arch-Line BHF, draw Lines to the Centre, to represent the Joints of the Nich; and describe the Crown *ce* according to the Thickness of the narrowest Part of the Courses. Then take a Piece of Plank, as is represented in *Figure LXVII*, and upon it draw a Quadrant *bd*, equal to BH or FA, and cut the End *ab* off, to answer the End AB in *Fig. LXVI*, and set the Thickness and Summering of the Brick, mark'd 2, on the End thereof; so that 2 and 2 are equal to each other. This being done, plane the Piece to its Thickness, at the End *ab*, gradually to nothing at the Point *d*; and take *cD*, *Figure LXVI*, which is half of the Diameter of the Crown, and set it from *d* to *e*, and lay a straight Rule from *c* through *e* to *f*,
N
and

and cut the Piece off at *ef*. Then does the Mould *abfe* answer to every Course in the Nich. And mark the Cross Joints upon them, setting one Foot of your Compasses at D, according to their Brackets on the Edge of the Mould, whereon you have all the Bevels, Lengths, and Thicknesses.

P R O B L E M L.

How to work a Level Arch in a Circular Wall.

F I G U R E LXVIII.

FIRST strike the Sweep AD, representing the Wall wherein the Arch stands, and thereon set BC, the Width of the Door or Window. Then draw the Lines BI, CI, and set the Width of the Surface from B to *l*, and from C to *m*, and strike the Arch *lm* from I. This being done, strike the Arches EF, GH, from the same Centre, after the same Manner as the Arches BC, *lm*, only letting them be so much the longer, as are the two Skew-Backs of the Arch; then halve BC at N, and EF at O, and set the Mould EFGH, perpendicularly over the Mould BC, *lm*, and so much above it as you design the Surface of the Arch shall rise, the Point O being perpendicular over N. Then on the Centre I raise a Perpendicular to K, letting IK be equal to NO.

This being done, set the Courses on the Arch EF, according to the Thickness of the Bricks, or Stones, you work with. Also divide the Arch BC into so many equal Parts, as EF, which give the Thickness of each Course at the Bottom of the Arch. Then strain a Line, or lay a straight Rule from the Perpendicular at K to the Divisions or Joints of each Course on the Arch EF, beginning at E or F, and draw Lines to the Arch GH, shewing the Summering at the Top of each Course, according to the Sweep of the Wall. Again, draw Lines from the Divisions of the Arch BC, to the Arch *lm*, pointing to I, which shews the Summering of each Course at the Surface; and so
you

Fig. 64.

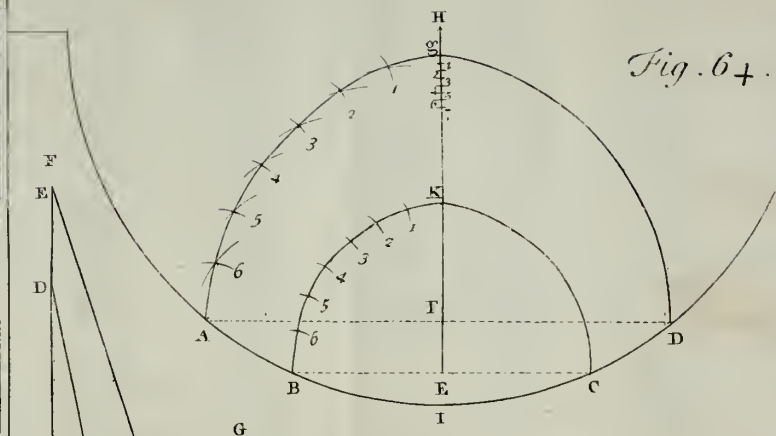


Fig. 65.

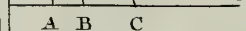


Fig. 66.

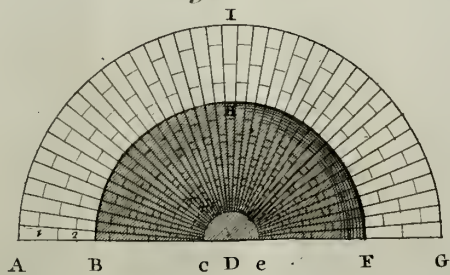
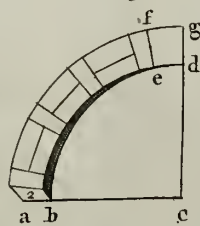


Fig. 67.



you have the Width and Summering of the Mould given for the Surface of each Courſe on the two Arches EF, BC.

But the Croſs-Joints are found thus: Take a Bevel, whoſe Stem is long enough to reach from C to F, and ſet thereon, placing the Blade to the Arch EF towards O; and this gives you the Croſs-Joints for the firſt Courſe. Alſo ſet your Bevel on the Next Diviſions to C and F, and place it after the ſame Manner, for finding the Croſs-Joints in the ſecond Courſe; and ſo of the reſt.

P R O B L E M L I.

How to work an Arch for a Bow-Window in Brick or Stone, which is a Semi-Circle, and ſwells a Scheme.

F I G U R E LXIX.

FIRST deſcribe the Sweep AF, to represent the Wall wherein the Door or Window ſtands, and ſet on the Width CD, BE. Then erect a Perpendicular Ot, on the Centre O of the Arch AF, and ſtrike the two Central-Arches BsE, CzD, to answer the Out-Lines of the Tops and Surface, by the Rule laid down in *Problem LXIV*. Which when done, put them into their due Poſition, letting z and s be perpendicularly over q. Then will Qz be equal to the Semi-Diameter of the Window, and divide the Courſes on the Arch BsE, according as they are Brick or Stone, and divide the Arch CzD into the ſame Number of Parts as BsE. This being done, take a ſmall Line, and ſtrain it from the Centre O to C, bringing it round on the Surface to B, and from B to O again. Then take the Height from the Line CD, to the firſt Diviſion on the Arch CzD, at 1, and ſet it up perpendicularly from O towards t; from whence ſtrain the Line to 1, bringing it round on the Surface to 2, from whence ſtrain it level to the Perpendicular again. Then take the Height from the Line CD to 3, and ſet it up perpendicularly from O towards t; from whence ſtrain a Line to 3, and bring it round on the Surface to 4; from

from whence strain it level to the Perpendicular again, and so on. As may be seen by the Courses *m p*, and *g n*, letting the Lines remain on the Centres and Perpendiculars, that give the Summering, Twiftings, and Bevels, of every Course, from whence you are to make the Moulds, and take the Bevels.

Note, The Point O must be level with BCDE; and also the Lines that are strain'd from the Perpendicular to the Centre.

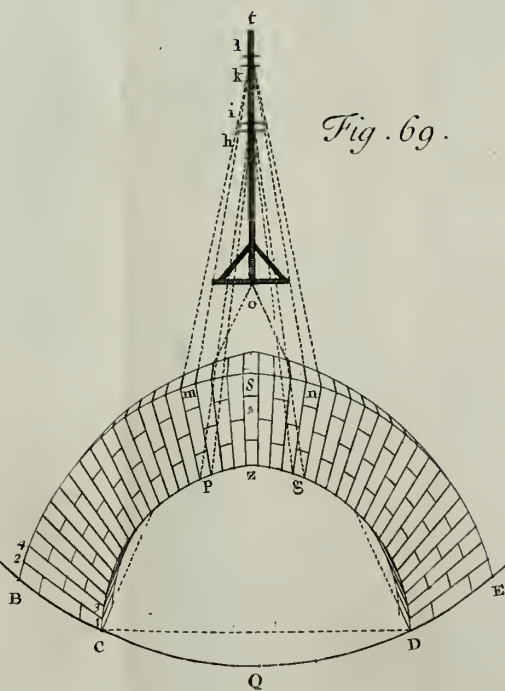
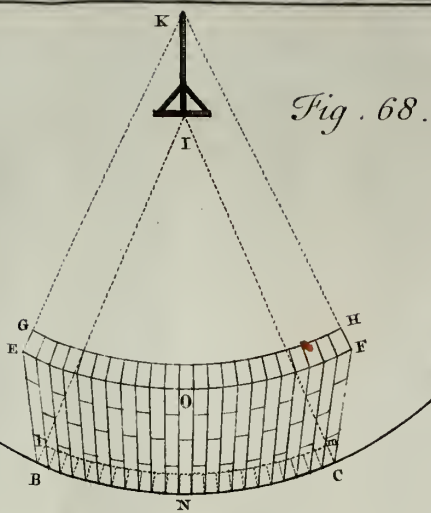
P R O B L E M LII.

How to work a Regular or Irregular Groin in Brick or Stone.

F I G U R E LXX.

REPRESENTS the Centre for an Irregular Groin, where KL is ten Feet, and OH eight Feet. Divide the Backs or Circumferences OQH, KFL, into any equal Number of Parts, according to the Thickness and Quantity of Courses contain'd on the larger Centre KFC. Then will the Divisions or Thicknesses of the Courses on the lesser Centre OQH be something thinner, and your Bricks or Stones must be provided accordingly, and so you will prevent dropping of Courses. This being done, on those Divisions strike Chalk-Lines, which are represented in the Example by Prick'd Lines; and these are the true Guides by which the Courses must be work'd level, and also to take the Bevels of the Groin.

Having done this, begin to work the first Groin-Brick after the following Manner: Take the Bevel 1 on the Centre, and set it on the Edge of the Brick R, and from the Bevel strike a square Stroke on each flat Side of the Brick, to which cut the Levels of the first Brick. For the second Brick, set the Stem of the Level 2 on the first Line, and the Blade thereof to the Arch or Curve of the Centre, and this Bevel set on the Edge of the Brick D: Then take the Bevel 4, and set the Stem to the second Line 3, on the
same





same Centre, turning up the Blade on the other Centre; to answer the Summering of the second Course, which Bevel set on the upper Side of the Brick D from the Bevel 2; to which cut the Bevels of the second Brick, and place it in its Position, and you will find that it does not answer the Summering of the Course on the reverse Centre; to do which, make a Mark on the Brick where it touches the second Line on the reverse Centre, and set back the Width of a Course from that Mark to the upper Edge of the Brick where it shall so fall out, and from thence strike a Line to the first Mark at the second Line, as also to the upper Corner of the Brick at the Curve of the Centre, to which cut the second Brick, (according as they appear in the Examples C and E,) which answers the Summering of both Courses; and observe that as much as you take off from the upper Side to answer the reverse Course, so much you must add to the under Side by a Clofier, the Figure whereof appears in the Example F; which, if simmer'd to the Brick, will add much to the Strength and Beauty of the Work.

Now find the Bevels and Summering of the third Brick thus: Set the Stem of the Bevel 3 and the Blade to the Curve of the Centre, and then set the Bevel on the Edge of the Brick B, which done, take the Bevel 4, and set it on the third Line, on the same Centre, turning up the Blade thereof on the reverse Centre, to answer the Summering of the Course, which set on the flat Side of the Brick B, from the Bevel 3; to which Bevels cut the third Brick, and place it in its Position; then make it to answer the Summering of the reverse Centre, as has been before taught, by marking the Brick where it touches the Level-Line on the Centre, and cutting back the Width of the Course, and cut the Clofier accordingly. And thus proceed on till you have gone so far with your Groin, that the Summering turns up the Brick its whole Thickness above the Level-Line; and then the Remainder of the Groin must be all Headers and Clofiers; but the Bevels are taken the same. Only observe that instead of placing the Stem of the first Bevel on the Edge of the Brick, you must place it on the End, as in the Example on the Brick N shews, and so on; observing that as your Clofier increases in Thickness, from no-
O thing

thing at the Springing, so it must decrease to nothing at the Crown. And thus any Regular or Irregular Groin may be work'd.

Figure LXXI. shews the Inside of the Groin after it is finish'd; where you may see by the Clozier the Summering of each Course, and the Bevel of every Brick.

P R O B L E M LIII.

How to diminish a Column, or Pillaster.

F I G U R E LXXII.

WHEN the Heighth and two different Diameters of the Column are given, proceed thus: Divide the whole Heighth into three equal Parts, and draw the first third Part from A to B, perpendicular to the Base; and from B draw a Cross-Line parallel to the Base; upon which describe a Semicircle, having its Diameter equal to the Diameter of the Column below. Then draw a Line down the Middle of the Column, or Pillaster, as DE perpendicular to the Base.

This being done, take half of the Diameter of the Column above, and set it both Ways parallel to the Base, from the Middle Line ED to the Arch of the Semicircle before described, where it shall so happen, as at 66; and divide that Part of the Circle from the Springing of the Arch to the Points 66 into any Number of equal Parts, as six, and draw Lines parallel to the Base, to the correspondent Divisions on each Side the Circle as 11, 22, 33, 44, 55, 66. Then divide the upper Part of the Column, from B to the under Side of the Astragal on the Neck of the Column into the same Number of Parts as you did that Part of the Arch between the Springing and the Point 6, which is 6, and at each Division draw Lines a-cross at Right-Angles to the Middle-Line ED, and take half the Line 11 in the Circle, that is, from the Middle to 1, either Way, and set it both Ways on the Line 11, upon the upper Part of the Column. Moreover, take half the Line 22,

on

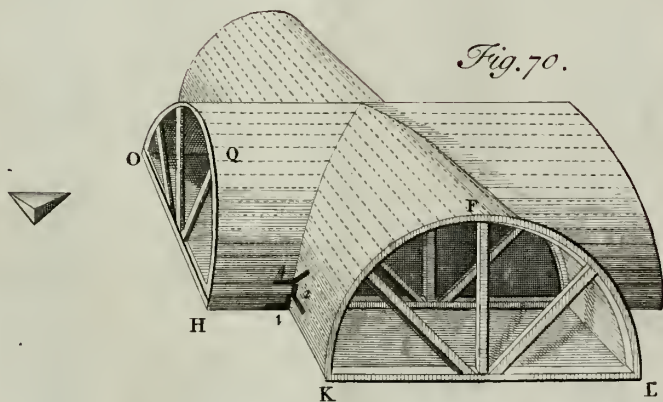
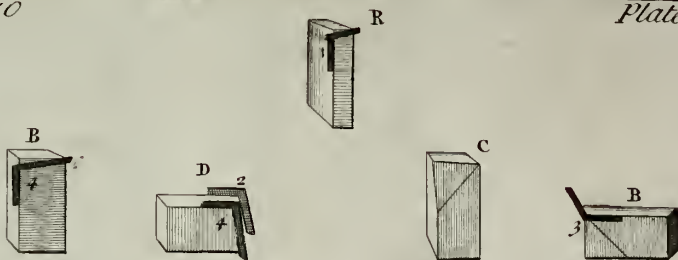
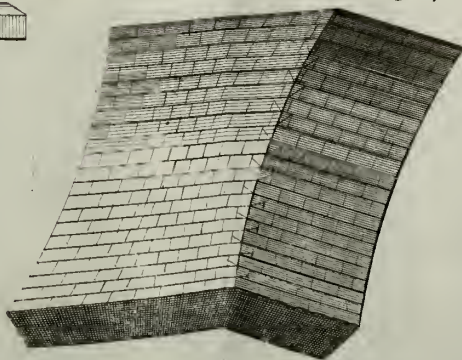


Fig. 71.





on the upper Part of the Column, and so on; and the six Lines in the Circle are equal to the six Lines on the Part of the Column; and in the extreme Points stick Nails, and bend a thin Lath round them, so that it touches each of them; then with a Pencil, or any other Marker, describe the swelling Part of the Column that is generated by the Circle, which, when drawn upon a Board, is a Mould to work by.

P R O B L E M LIV.

How to work a Diminishing Pillaster in Brick.

F I G U R E LXXIII.

FIRST make a diminishing Rule to fit the whole Side of the Column, or Pillaster; and if it be large, so that a Board will not reach the whole Length, you must make it several Lengths, always observing to keep the Rule in its proper Place, according to what Part of the Column it belongs, then begin to work. The Example F is the first Course, and the Example G the second, and those continue perpendicular all of the same Bigness to one third Part of the Height of the whole Column, that is, from the Base to the Course AB, and from thence it diminishes something to the Collar of the Capital; the Out-lines being drawn according to the Rule in the foregoing Problem, divide your Courses all of one Thickness, and divide the breaking Joints, so that they be parallel to the Out-lines as in the Example; as the Course AB consists of two Streachers and one Header, which is the half of a Streach, and must be divided into five equal Parts, being two to each Streach, and one to the Header, and so of the Courses *ef, ik, pq, and tu*, they bearing the same Proportion to each other, tho' they are shorter, by reason of the Diminishing. The Course *cd* consists of two Headers, one Streach, and two Closters, and must be divided into ten equal Parts, because two Closters are equal to one Header, and four are equal to a Streach. Understand the same of the Courses *cd, lm, no,*
and

and *rs*, they all bearing a Proportion to each other, after the like Manner. Then upon those Divisions, whereon the Joints are to come, as may be seen by the Dots in the Example, stick in small Nails, and, as in the last Problem, bend a thin Rule about them, and with a Marker describe the Cross-Joints, which will diminish parallel to the Out-lines.

P R O B L E M LV.

How to work a Diminishing Column in Brick.

F I G U R E LXXIV.

FIRST describe the Out-lines of the Column, and the Thickness of the Joints, as in the foregoing Example, and draw the Plane of each Course, as *hi*, from whence the Arch, Diminishing, Length, Width, and Bevel, of each Brick is found. One Third of the Column from *ab* to *ab* is perpendicular, and from *b* to *b*, it is somewhat swelling, according to *Figure LXXII.* therefore you must work thus :

Rub the Bricks all to one Thickness, and take a Block just the Thickness of the Bricks you work, and about three Inches square, and set the Centre thereof just over the Centre of each Plane, and nail small Fillets about it, on the Board upon which the Plane is drawn, to confine it in its Place without nailing it down, because hereafter you will have occasion to take it off, and set it on at every Brick you work, the Use thereof being to raise equal to the Heighth of the Brick ; so that you shall strike the Arch and Bevels thereof without Moulds, which would be troublesome in the diminishing Part of the Column ; but in the perpendicular or upright Parts, you may work with Moulds taken from the Planes, because one serves for all of that kind. But I shall proceed thus :

Take the first Brick, and lay it upon the Plane of the Brick 12, in the Plane *b* ; then take half the Diameter of the Pillar, or Column, in your Compasses, and set one Foot in
the

the Centre on the Block, and with the other strike an Arch on the flat Side of the Brick to answer the Outside of the Column. This being done, take the Distance 12, 23, or 34, and set it upon the Brick or the Arch, and on the extreme Points lay a straight Rule to the Centre *b*, and along the Side thereof mark the Joint or Summering of the Brick; then take it up, and from these Joint-Strokes square over the Edges thereof to find the Joint-Strokes on the other Side of the Brick, upon which draw the Joints or Summering; as also an Arch equal to the former, by setting the former one first to fit on the Arch of the Plane. Then, with your Compasses opened to the same Distance as before, setting one Foot in the Centre on the Block, with the other strike an Arch on the other Side of the Brick. Then you will have the Joints, Arch, and Summering of the Bricks; and so of the rest, &c.

Now work the diminishing Part of the Column thus: First take off the Block, and then take half of the Diameter of the Column at the Joint 1 in your Compasses, and setting one Foot in the Centre *b*, with the other strike a Circle within the Circle of the Plane, which Circle Mark 1: Also take half the Diameter of the Column at the Joint 2, and setting one Foot in the Centre *i* in the Plane *i*, with the other strike a Circle equal thereto. Moreover, take half the Diameter at the Joint 3 in your Compasses, and setting one Foot in the Point *b*, in the Plane *b*, with the other describe a Circle. Again take half the Diameter of the Joint 4 in your Compasses, and setting one Foot in *i*, with the other describe a Circle, and so on; also describe a Circle, whose Diameter shall be equal to 5 in the Plane *b*, and a Circle whose Diameter shall be equal to the Joint 6 in the Plane *i*, and so of 7 and 8, and the rest to the Capital of the Column; and always observe to draw the Circle that represents the under Side of each Course in the Plane to which it belongs, that is, if it be all Streachers to *b*, if it be Headers, Streachers, and Closters to the Plane *i*.

Having the Circles all drawn to represent the under Side of each Course, set the Block in its Place, and begin to work the diminish'd Courses mark'd thus: Take a Brick, and lay it upon the Plane, as is taught before; then take half of the Diameter of the Circle 1, in the Plane or the Joint 1, on the Column, in your Compasses, and setting

one Foot in the Centre *b*, on the Plane *b*, with the other strike an Arch on the Brick, to represent the Outside of the Column of the Joint 1. This being done, lay a straight Lath from the Centre *b*, on the Block, to the Point, letting it lie perpendicular over the Line 1 *b*, and along the Edge thereof strike the Joint or Summering of the Brick; also lay a straight Lath from the Centre *b* to 2, perpendicularly over *b* 2, and turn the Brick upside down, and set the Arch and Cross-Joints just on the Arch and Cross-Joints of the Arch 1 in the Plane *b*; then take half the Diameter of the Arch 2 in the Plane *i*, or half the Diameter of the Column at the Joint 2, and setting one Foot in *b*, with the other strike an Arch on the other Side of the Brick, and mark the Joints or Summering of the Brick as before, by laying a straight Rule from the Centre *b* to 1 and 2. This being done, cut the Arch on the Brick to represent the Outside of the Column; which, when done, draw the Cross-Joints on the outward Edge of the Brick from the Lines on each flat Side thereof, which cut to these Lines, and you will find the Brick and Joints to answer the true Diminishing of the Column. Understand the same for the rest of this sort of Courses.

To work the Courses mark'd 2, take a Brick, and lay it end-ways upon the Arch 2 in the Plane *i*, at 4 and 5, and keeping the Compasses at the same Distance as when they struck the Arch on the upper Side of the Brick mark'd 1, in the Plane *b*, which is half the Diameter of the Circle 2, or Semidiameter of the Column at the Joint mark'd 2, and setting one Foot in the Centre *i*, with the other strike an Arch on the upper Side of the Brick; then lay a straight Rule from the Centre *i* to 5, and strike the Summering of the Brick. Moreover, as before taught, turn the Brick upside down, and set the Arch and Summering Stokes or Joints of the Brick to the Arch 2, and the Cross-Lines 4, 5. This being done, take the Semidiameter of the Circle 3, that is, the Semidiameter of the Column at the Joint 3, and resting one Foot in the Centre *i*, with the other strike an Arch upon the upper Side of the Brick equal thereto. Then, as before, lay a straight Rule from the Centre *i* to 4 and 5, and upon the Edge thereof set on the Summering Joint, upon the upper Side of the Brick. When you have done this, cut the Arch on the End of the Brick, as also
the



the Summering Joint, which, when done, is a Header to the Course mark'd 2, and answers to the diminishing and true Joints of the Work, the Streachers and Clofiers being mark'd after the same Manner; and so of the rest of the Courses which when done, the Work is finish'd.

N. B. The Circles, mentioned in the foregoing Problem, are not inserted, because the Scale being so small would not contain them; and observe to number them as the Joints on the diminishing Part of the Column, because they are equal to each other.

P L A T E XIV.

Represents two Raking-Collonadoes on the Side of a Hill, wherein Walks are cut; and they are here inserted only to shew the Use of Raking-Arches, such as may be seen on the Side of *Richmond-Hill*, leading to the old Wells.

P L A T E XV

Represents three Flights of a Stair-Case with the Ceiling under the Gallery, or Landing-Place, under which the Point of Sight is taken; and they are here represented to shew the Use of the following Machine in *Plate XVI.* which is to turn Raking-Mouldings, Ballisters, or any other Raking-Work of that kind, which, in my Opinion, would be very beautiful in this kind of Stairs, to have the upper Mouldings next to the Hand-Rale, to rake equal thereunto, but the lower Mouldings next to the Step to be square answerably.

F I G U R E LXXVIII.

IS the Machine, the Nature of which may be seen at one View, by lifting up the Handle of the Bow wherein the Swivle of the Crane turns, which will cause the Socket thereof to turn out of a Perpendicular, the Swivle to which the Ballister is fasten'd, being let therein must consequently draw too and fro, so much as the Crane turns out of a Perpendicular: Therefore so much as the different Mouldings rake, you must lift the Handle higher
or

or lower accordingly ; and if you have occasion to turn Square-Work, move the Handle down to the Bottom of the Mortise, and then your Work will be level, and turn perpendicular. The different Parts of this Machine are put together in the following Manner: The two Gaugings of the Bow A are let into two level Pieces on each Side the Puppet-Head, so that the Eyes in which the Spindle of the Crane turns are level with the Spindle to which the Ballister is fasten'd, and the Bottom of the Mortise in the Puppet-Head must be level with the Gaugings of the Bow. The Eyes BB frame into the Plate of the Bow A, and CC are the Keys to fasten them. On the under Side D is the Swivel which goes thro' the two middle Puppet-Heads; the one End fits to the Socket of the Crane, and the other to the Box that fastens the Ballister. E is the Box which screws on to the End of D; *f* is the Nut to fasten it on; and *g g* are the Screws that fasten the Ballisters into the Box E. H is the Mandrel that goes thro' the Puppet-Head, whereon the End of the Ballister turns, by boring a Hole in the End of the Ballister something deeper than the Rake of the Mouldings, because of its sliding to and fro. I is the Spindle of the Crane that is let into the two Eyes B B; and *k* is a round Nut that fastens the Spindle I into the two Eyes B B. L is the Draught of the Ballister which all Turners must have before them, to find the Rake of each Moulding. M is the Socket in which the End of D goes; the upper Hole thereof must be a very little bigger than the End of the Spindle, and the lower End must be so large, that when the Handle of the Bow is lifted up to the Top of the Mortise, the Inside of the Hole shall be perpendicular.

F I G U R E LXXIX

Is the Plane of the Lath ; and N, O, P, Q, are the Mortises wherein the Puppet-Heads stand.

F I N I S.

Fig.75.

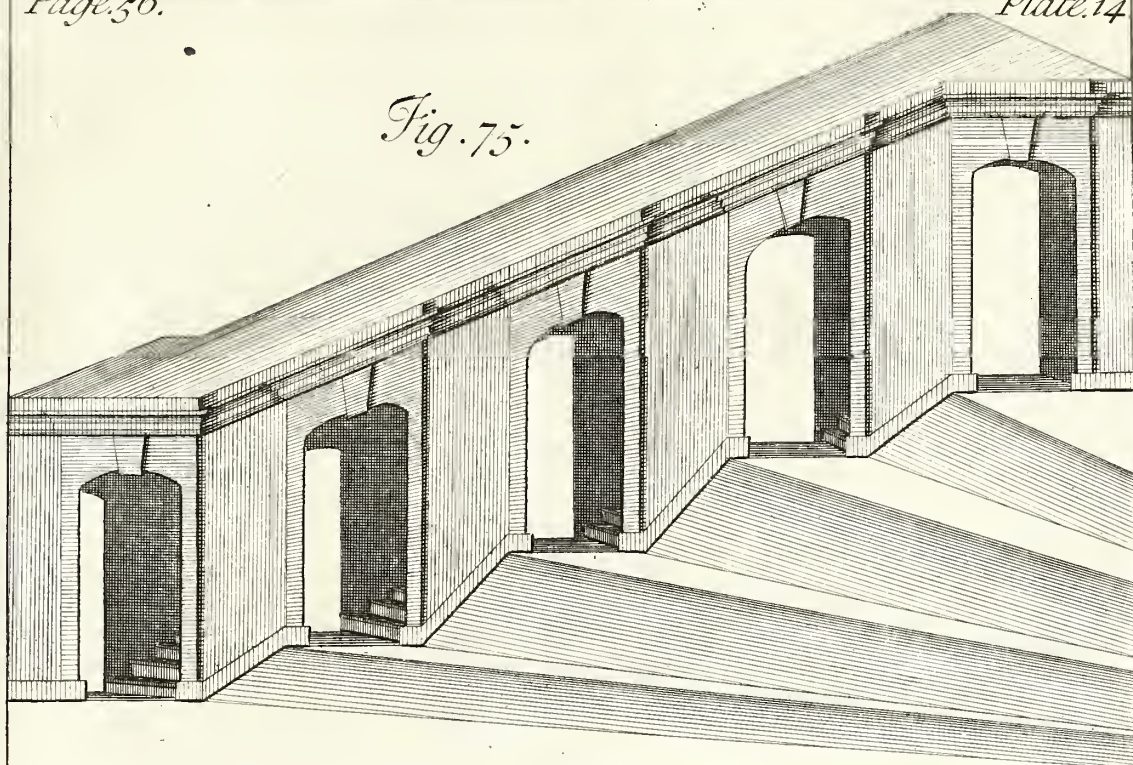


Fig.76.

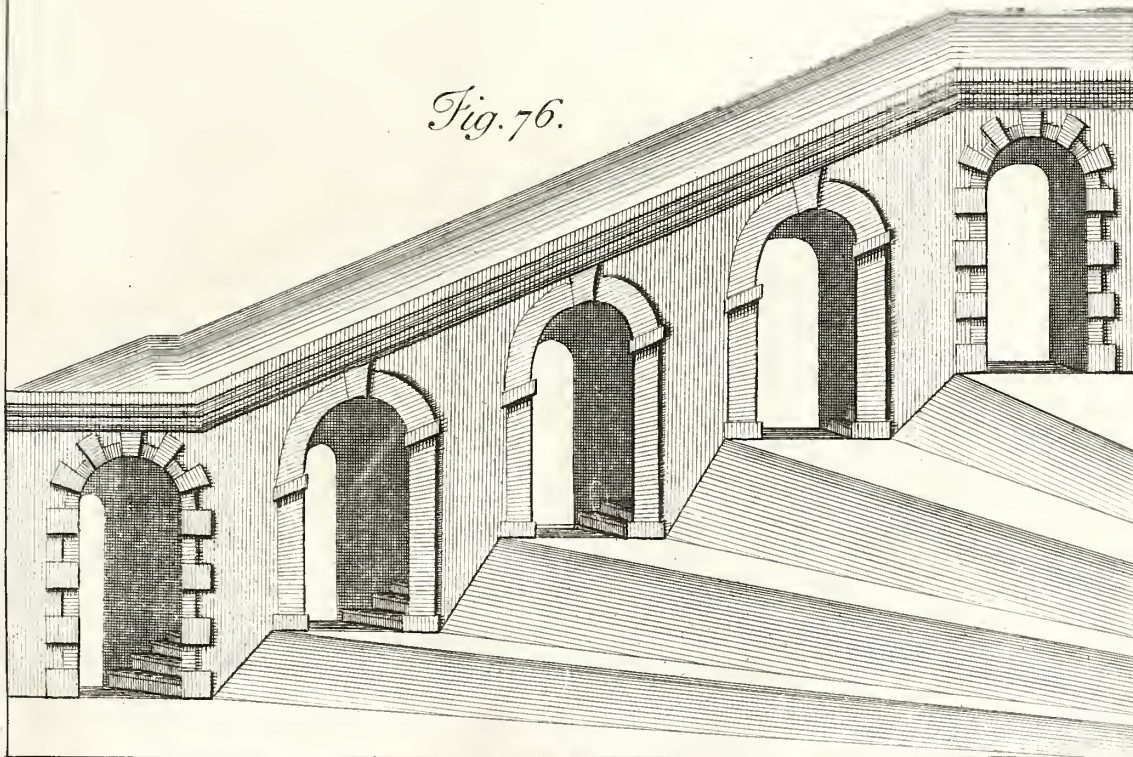




Fig. 77.

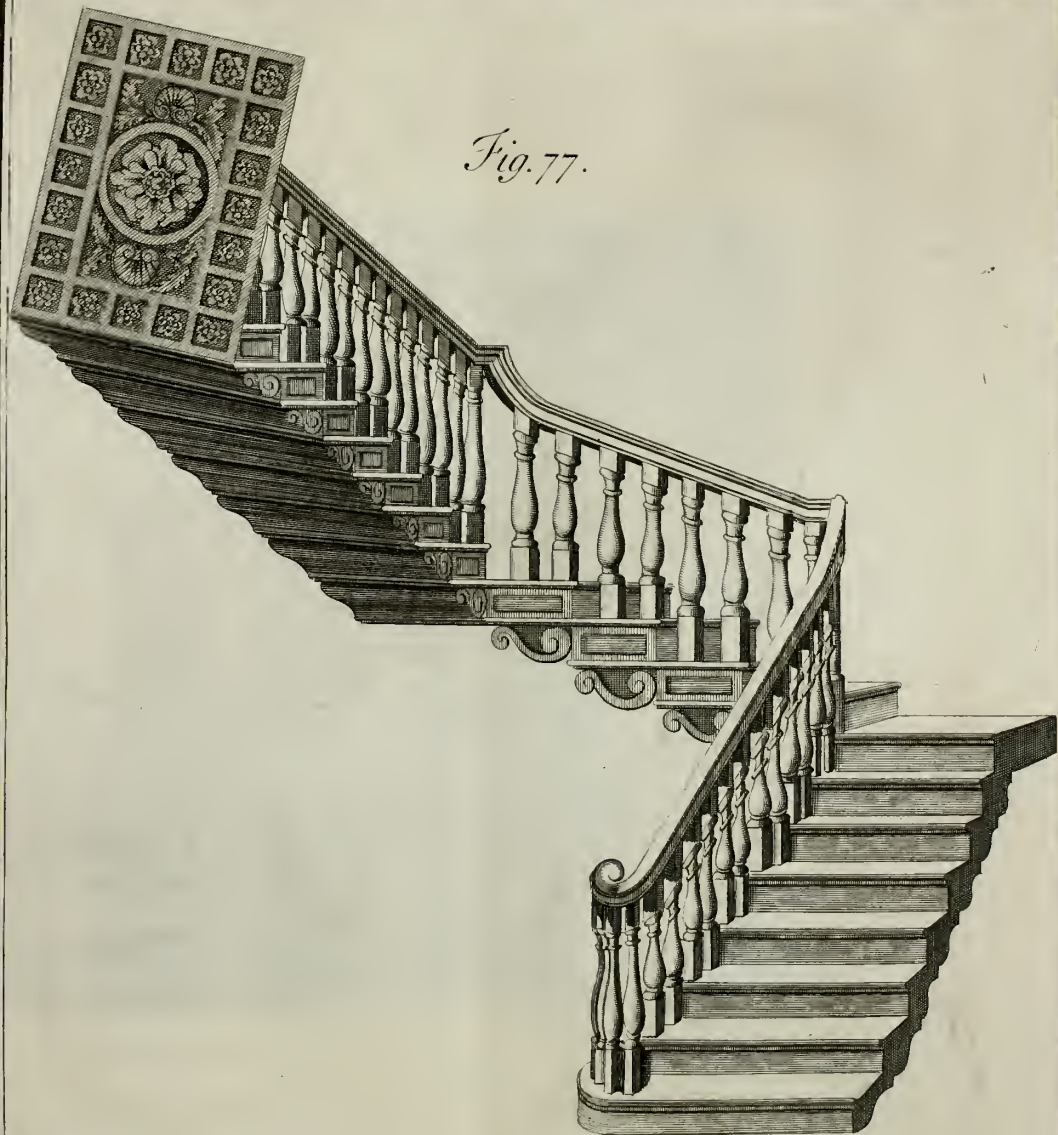


Fig. 78

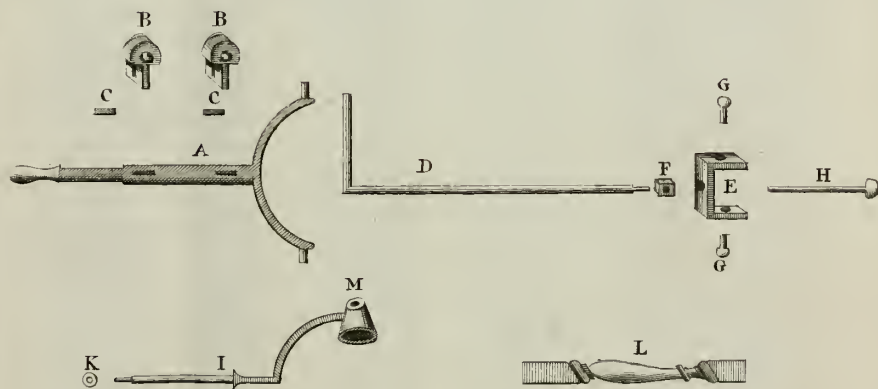
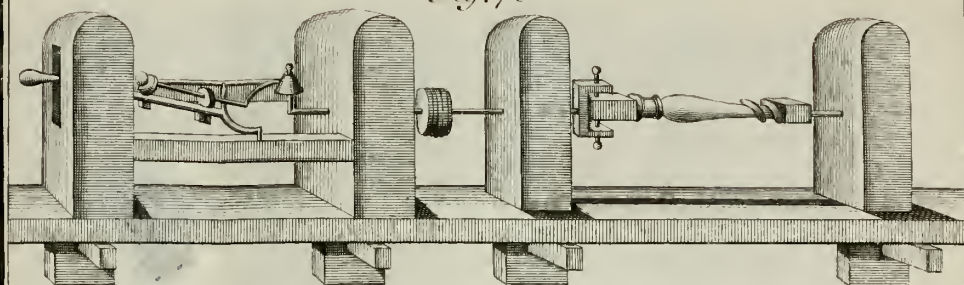
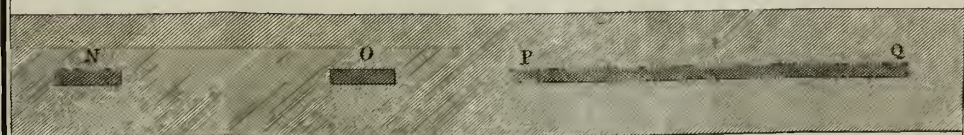
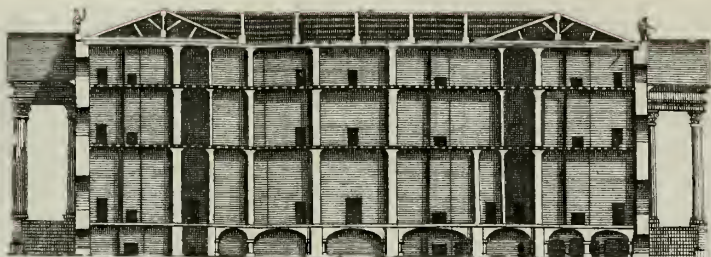
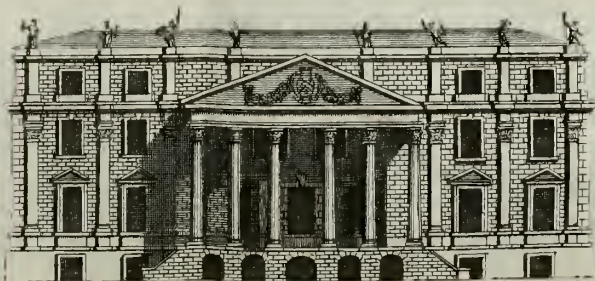


Fig. 79





The ELEVATION, & SECTION, of a HOUSE of my INVENTION,
with y^e PLAN S, & SECTION, as in the following Plates



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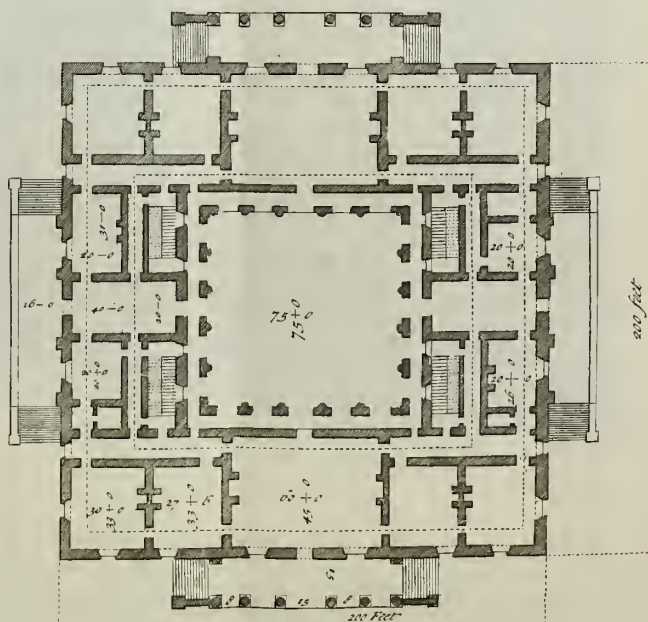
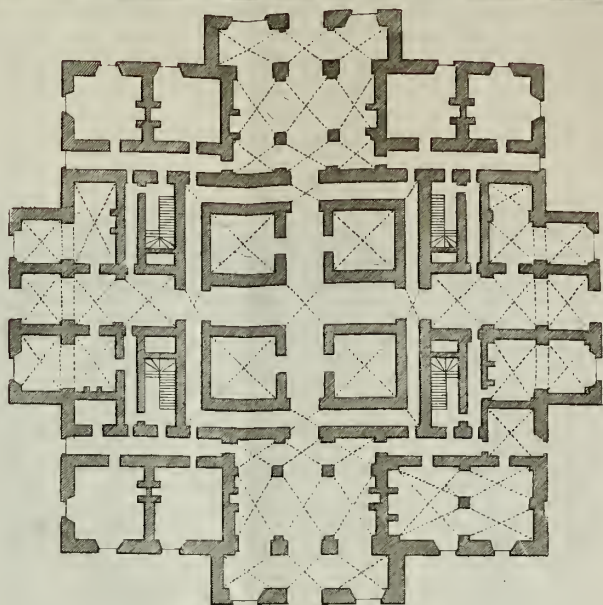
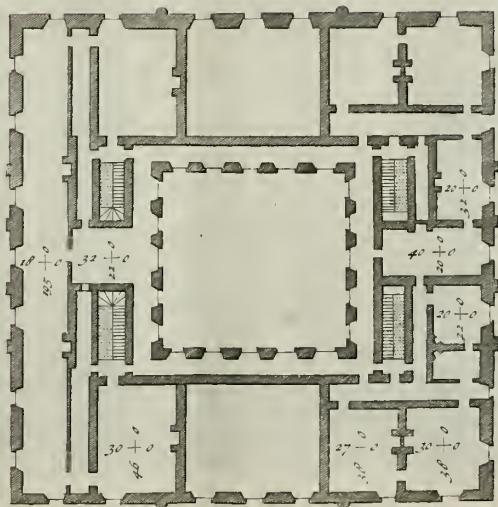
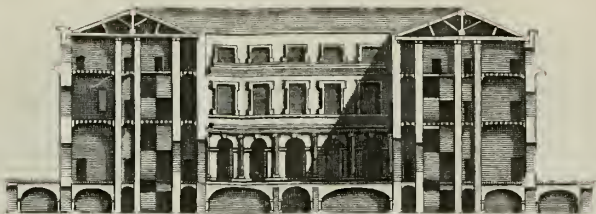


Table with 2 columns and 10 rows of text, mostly illegible due to blurriness.



The Chamber Plan, and Section.



This Church is of my Invention for Leeds in York-shire.



ERRATA.

PAGE 5. Figure VII. Line 4. read as are drawn in Figure VI; p. 7. l. 1. r. Line CE, which halve in the Point D; p. 10. Fig. XV. l. 5. r. Then taking CE; p. 12. Fig. XVIII. l. 1. r. halve it at C; *ibid.* l. 5, & 6. dele the Words and draw the Lines AD and BF; p. 13. l. 7. r. Scheme under a Semicircular Arch; p. 15. Fig. XXI. l. 7. r. Lines AG, and DH perpendicular to AD; p. 16. Fig. XXII. l. 8. r. AG and DH; p. 18. l. 9. r. lg; *ibid.* l. 10. r. Line fl; p. 19. Fig. XXV. l. 2. for equal r. unequal; p. 20. l. 4. r. Lines OP, ST, VZ, LM, and IK; *ibid.* Fig. XXVI. l. 6. r. Arch vzt; p. 22. l. 15. r. Lines zn, nk, and ok; p. 23. in the two last Lines but one of Fig. XXVIII. dele drawn from the Extremities of the Perpendiculars; p. 28. l. 22. r. Arches p and q, over E; p. 29. l. 4. r. DR for DK; p. 30. l. 5. r. as AH; *ibid.* l. 15. for baste r. baste; *ibid.* l. 21. r. lh from o to k; *id.* *ibid.* for baste r. baste; p. 31. Fig. XLII. l. 7. r. Lines aG, ah, aO, are drawn; p. 35. Fig. XLVIII, XLIX, L, LI. r. uv to ml; p. 48. Fig. LXX. l. 18. for Bevels r. Levels.





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